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B. BURGESS, CAPTAIN,
Secretary.

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LIEUT.-GENERAL HENRY BRACKENBURY, C.B., R.A., Director of Military Intelligence, in the Chair.

THE TACTICS OF COAST DEFENCE.

By Lieutenant-Colonel WALFORD, h.p., R.A.

"THE tactics of coast defence" have, I believe, never been brought forward in any distinct form, and I have failed until recently to find any works on the subject either in our own or in foreign languages. I hope, however, to be able to convince you, not only that this study is the natural outcome of our continued advance in matériel and in training, but also that it is well worthy of careful investigation, since on an intelligent comprehension of its principles will depend the construction and handling of the various works and engines of defence which we are, at great cost, accumulating in all parts of the world.

It is universally acknowledged that field tactics form an integral portion of the art of war, teaching as they do the system of the employment of men and weapons in actual battle; the tactics of siege operations are also, by common consent, allowed to be worthy of study; why then should any one deny that coast defence, which also has its peculiar form of combat, should alone be incapable of inspiring a peculiar system of tactics. This denial is based, I believe, on two causes.

i. A conviction that tactics imply movement.

ii. The fact that coast tactics require for their comprehension some knowledge of another branch of our forces, viz., of the Navy.

If we examine these in turn we shall, I believe, find that we have merely denied that which we do not rightly understand, and have indeed attempted to blind our eyes to the necessity of knowledge by strenuously asserting that no such knowledge exists.

i. *The Conviction that Tactics imply Movement.*

This conviction (which in some of us may, I hope, be rather styled an impression) has sprung from the narrow limitation which it has been customary to set to the meaning of the word "Tactics." Field tactics, as I said just now, have in these days a distinct meaning in the minds of the majority of soldiers, but it is not very long since some of us regarded them as "theory" (a word which always tends to most please those who least grasp its meaning), and condemned them on the ground that they were unpractical in the field; this school is, let us hope, moribund if not extinct; it has been killed by the very god it served, practical experience in war. Others again have confused tactics with drill, the end with the means, or rather with only one of the means, since discipline and organization have an important share in rendering tactics possible.

A considerable number among us still regard "the tactics of coast defence" as being a contradiction in terms, owing to the fact that no movement of troops is possible under the conditions of the defensive action of forts. These pass over, I think, the fact that the essence of pure defence in the field is also immobility, and in saying this I do not forget the absolute necessity of the after-action of the counter-attack. The counter-attack is undoubtedly impossible in coast defence, of which the character must be purely passive. But since we acknowledge the existence of a system of tactics in passive defence in the field, why is such a system impossible in passive defence on the coast?

If we look a little deeper into the matter we shall, I think, be inclined to agree that the word "Tactics" expresses the working of armed troops under fire, whether they be halted or on the move.

ii. *The fact that "Coast Tactics" is not entirely a Military Question.*

By the nature of their respective services the Army and the Navy have little opportunity of gaining experience as to the character of each other's action. Soldiers and sailors, in their capacity as such, meet only under two circumstances, viz.:—

a. When a naval brigade serves on shore.

b. When troops are embarked on board ship for the purposes of transport.

In the former case the Navy are taken from their own work and are employed in soldiering; I do not say that we may not, and do not, learn something from them, but, well as they work on shore, the fact remains that it is our profession to fight on land, and it may be assumed that we know something of it. In any case we can thus learn nothing of the essential duties of a sailor, or of his manner of fighting on his native element.

In the second case, as soldiers are rarely embarked on a fighting ship, they can learn nothing from their experience save great respect for the regularity of the discipline of the ship and for the handiness

of the crew. Of their fighting conditions we can know nothing, their fighting tactics we cannot even guess. How then can we be expected to appreciate the existence of a system of tactics for ourselves which by its nature must be dependent upon that in use by the Navy?

It is an axiom in war that the tactics of the defence are derived from those of the attack, and it is moreover certain by the conditions which affect engagements between ships and forts that the action of the former will be always offensive, while that of the latter must be limited to a purely passive defence. It therefore follows that, in order to arrive at the principles of the tactics of coast defence, we must first enquire into those of the attack of a coast fort or fortress by a naval force.

Let us then examine some of—

II. *The Conditions under which an Action may take place between a Naval Force and a System of Coast Defence.*

The principal of these appear to be as follows:—

a. The ships can choose their moment for attack and their moment for ceasing to attack, provided always that they retain their mobility.

b. On the other hand, the attack must be made, as a rule, over a space of which every detail should be known to the defence; that is to say, the attack has seldom the privilege, except in a very limited degree, of choosing the point of attack or the road to that point.

c. Since the road to the point of attack will have been certainly foreseen, it will generally be obstructed beforehand with serious obstacles.

d. The ships will therefore be compelled, almost without exception, to devote in future some considerable amount of time, and much of their strength, to the destruction of these obstacles, before they will find it possible to commence the decisive attack.

e. The efforts made to destroy these obstacles will clearly point out to the defence (even if they were previously in any uncertainty) the path of the coming assault; temporary expedients for further obstruction will undoubtedly be used.

f. Where obstacles are provided, and their use is understood, there will, therefore, no longer be any possibility of hastening the completion of an operation by dashing in to close quarters, except at the risk of the destruction of such ships as advance too rashly.

g. The ships will thus, even under the best system of supply, be generally obliged to economize their ammunition, since they may at any time be called upon to fight a relieving squadron.

On the other hand, the fortress, unless it be invested on the land side, will usually be able to renew its supplies, and is not therefore bound to economy. An exception is, of course, to be found in the case of a Colonial fortress which has no communication with an arsenal except by sea.

h. Supposing the action to be fought out to the bitter end, a fortress

can do no more than repulse an attack; it has no power of pursuit, nor can it take advantage of the injury which it may have inflicted on the ships, for it cannot capture or destroy them.

The ships, on the other hand, in order to obtain a full success, *i.e.*, to actually capture the forts, must change their original mode of attack by fire into the weaker form of a landing by means of boats; in order that the latter may be successful, either the enemy must be utterly demoralized, or his powers of defence must have been altogether destroyed.

i. Assuming, however, that, as will generally be the case, the object of the attack is not so much the capture of the forts as the destruction of that which the forts were constructed to guard, the ships will, when once the action of the forts has been so reduced by fire that they can be held in check by a fraction of the squadron, be able to carry out their purpose by means of the fire of the remainder. In this case, a full success may be obtained, even though the forts have never passed from the possession of their defenders.

j. With regard to the respective disadvantages of the stationary platform with a moving target, and of the stationary target with a moving platform, the conditions have until lately been supposed to be of equal effect. But in the light of recent improvements, both in fighting machinery and in the conduct of action on shore, the advantage now certainly remains with the forts, for with the development which we may confidently expect in the system of coast defence, fire at a moving target will become as accurate and as rapid as practice at a motionless object. In the matter of position-finders and range-finders, the defence has an enormous advantage over the attack.

III. *The Probable Principles of the Attack by a Naval Force, with some Remarks on the Defence.*

These may be best examined under the following heads:—

i. A surprise with a definite object, such as the destruction of stores, the cutting-out of ships, &c.

ii. An attempt to force a passage, or to run past the forts, in order to reach an objective which lies beyond them.

iii. A bombardment from a distance of the defences, or of the points which they are intended to cover.

iv. An attack by a strong squadron with a definite purpose, but before the enemy's fleet has been driven off the sea.

v. A systematic attack by a large force, with the object of the ultimate capture and occupation of the port or harbour.

Of these, it is evident that i, ii, and iv depend for their success upon the rapidity of their execution, and that a known condition of readiness for defence, especially in the matter of obstacles, would probably prevent their being undertaken.

i. *A Surprise by one or more Ships, or by their Boats, for the purpose of destroying Stores, cutting-out Ships, &c.*

The great naval war from 1793 to 1814 is full of examples of this form of action; of these, the most brilliant was the cutting-out of the "Hermione" by the boats of the "Surprise" on the 25th October, 1799, a feat of arms which has rarely been equalled and never surpassed either at sea or on shore.

The conditions favourable to such enterprises do not vary very much from those which obtained at the beginning of the century, for they require, now as then, a dark night, a careless defence, and superior *morale* on the part of the attack; but they are now complicated by the electric light, the possible existence of submarine mines, and of quick-firing and machine-guns. The advanced position of modern forts tends also to render them more difficult of execution.

It will be necessary to say but little of them, since the best protection against them will obviously be found in systematic and constant patrolling by guard-boats, while if the element of surprise be thus eliminated, the action of the defence will resemble, on a small scale, the plan which we shall consider later, when speaking of the more serious forms of attack.

ii. *An Attempt to force a Passage in order to reach an Objective which lies beyond the Defences.*

Many examples of this form of action may be found in the history of the river fighting during the American War of Secession; but the details of these have but little value in the present day, owing to the altered conditions of war.

As might be expected, the ships generally trusted to their speed for success, reserving their offensive power for the objective beyond, and such, when possible, would probably be the course followed in these days.

The obvious counterstroke for the defence is to make high speed dangerous by the use of obstacles, and to cover these obstacles and the passage itself by the fire of guns. Recent improvements both in guns and mines will render the destruction of the latter far more difficult than was the case twenty-five years ago, while the fire of the former is both more effective and more accurate than it then was. The expedient of sending on an old ship in front against a line of mines would be of no avail except against mechanical mines (which are obsolete), while if the torpedo nets be lowered the speed of the ships must be diminished; ground mines will, even in that case, be effective.

It is, however, evident that, given the conditions which govern the laying down of submarine mines and the ranges at which guns will be effective against armoured ships, it will often be impossible, where the channel is of considerable width, to deny the passage of it to the attack, even though both shores be armed with guns and mines. But we may

reasonably suppose that such points would not be selected for the site of the defences intended to cover the passage, and that these would be withdrawn to a narrower part of the river or strait.

It must be remembered, however, that by so doing, the defence provides considerable facility for a landing on the part of the attack, and that an assault on the land front of a fort would materially interfere with the efficiency of its action.

iii. *The Bombardment from a Distance of the Defences or of the Points which they Cover.*

In the late war between Chili and Peru there were many examples of this form of action, towns and harbours being bombarded at a range of about 8,000 yards, and we have every reason to suppose that this system of attack, which is practically new to us, will be much used in the next naval war, especially by small squadrons or single ships, detached for the purpose of levying contributions, making a diversion, or of destroying some definite object. This system has, it is true, been called barbarous by many writers, especially by some French authors, but it does not appear to have received such universal condemnation as would justify its rejection as beyond the legitimate sphere of war.

The extreme range at which such a bombardment could be carried on would be limited by the amount of elevation permitted to the guns by their mountings or ports; the shortest range at which battle-ships would be safe from direct fire might be calculated with absolute accuracy, given the thickness of their armour and the character of the guns of the defence. Subject to correction, I venture to say that ships would invariably anchor in order to carry out a long-range bombardment.

To this mode of attack the defenders would oppose the high-angle fire of heavy howitzers, using common shell filled with high explosives, or armour-piercing shell, as might appear best after consideration of the details of each particular ship of the enemy. We have good reason to expect that this description of fire, even though it may in some cases fail to fatally injure the attacking ships, will at any rate force them to keep constantly on the move, in which case the accuracy and amount of their fire would inevitably be much diminished.

Night attacks by torpedo-boats (if necessary extemporized) would certainly be attempted, though, on the other hand, the bombarding ships may retire to a considerable distance at nightfall and return at daybreak. In this case it might be possible for the defence to lay down a system of submarine mines at the probable stations of the enemy's ships.

iv. *An Attack by a Strong Squadron, with a definite Purpose, but before the Enemy's Fleet has been driven from the Sea.*

The fact that the Power to which the attacking squadron belongs is not yet in full and undisturbed possession of the sea complicates this

form of action by the fact that the defence need only hold out for a certain time, or in other words, that the attack must be prepared to engage in a naval action, unless it can obtain a success before the relieving squadron can arrive. The difficulties of the attack are, therefore, much increased by the double necessity of saving time and of economizing ammunition, and this fact clearly points out to the defence that it is desirable to make them waste both.

It is probable then that, in this case, the efforts of the defence should be specially directed to delay rather than to repulse the attack, for the former mode of action will give time for the relieving squadron to arrive, and will tend to weaken the assailants in men and ammunition. If, on the contrary, the attack be permitted to come into close action with the forts, the issue of such action might be unfavourable to the defence; to permit it therefore would serve the purpose of the attack, by rendering it possible for them to bring about at once a favourable crisis.

These are, of course, instances where the use of obstacles is in great part forbidden by the nature of the coast-line; for example, had the Egyptians made use of submarine mines at Alexandria, they could have laid them only in the passes which led into the harbour, and could have gained no advantage from them on the scene of the main bombardment, that, namely, of the forts along the outer coast-line, from Pharos to Ras-el-Tin.

But where, as is usually the case, the harbour is either partially landlocked or lies in a bay, the delaying action of obstacles will be of very great advantage, playing as they do, when taken together with their covering forts and batteries, the part of the advanced defences of land fortresses, and in a similar manner keeping the enemy at a distance, obliging him to undertake a preliminary attack, and to carry it through before he can commence decisive action against the main defences.

But it must not be forgotten that we must still take account of the effect of long-range fire, and of the fact that by means of it a squadron can often perform its task without actually capturing any portion of the defences. This point concerns, however, rather the system than the tactics of the defence, and is a matter to be taken into consideration before hostilities commence, when selecting the sites of such batteries as are to be used for high-angle fire.

v. *A Systematic Attack by a large Force, with the Object of the ultimate Capture and Occupation of the Port or Harbour.*

It is to be noted that an operation of this kind will, in general, be carried out by a combined attack by sea and land; but in the present paper we have no concern with the latter portion, which, though identical in its aim, will be for the most part distinct in its design from the former.

We may in this case assume that any interruption of the attack by a relieving force is either impossible or a remote contingency, and that the assailants, being free from all need to hurry, will proceed by

regular stages, and in such a manner as will be most likely to ensure eventual success with the least possible expenditure of men and matériel. It is further worthy of remark that, since the attack intend to possess and make use of the captured port, harbour, or dockyard, they will not, except under extreme necessity, be inclined to destroy (by long-range fire or otherwise) that which, as they hope, may become their property. It is probable, indeed, that the attempt to so destroy any portion of the objective beyond the actual defences, may be taken, in many cases, as a proof that the assailants have given up the expectation to capture; it may thus often be the first sign of the intended abandonment of the enterprise.

Whereas in the former case the attack on the forts and batteries would have for its object to make them so far innocuous, that the attack should be able to carry out its work of destruction, the object in this case will be to drive out the defenders from them, and to actually seize and occupy them. It will not be sufficient to merely engage their attention—they must be silenced and captured.

Thus the destruction and passage of the mine-fields will be but a preliminary to the great artillery fight, and the whole action of the later stages of the attack will be more vigorous, as its effect will be more decisive.

Whereas, therefore, in the former case the fire of such ships as engage the forts will be principally directed with a view to covering the ships which bombard the objective point, and will thus be fairly evenly distributed over such batteries as can bear on those ships, we shall, I believe, find that, when absolute conquest is desired, the fire of certain designated ships will be concentrated on each of the defences in turn (commencing with those which are the most exposed) and continuing until the abandonment or surrender of each is compassed; other ships will probably be in the meantime employed in attracting the attention of such collateral forts as may be for the moment beyond the sphere of decisive action.

The arrangement of the defences in such a manner that no fort can be exposed singly to such an attack is, of course, a question of construction, in time of peace, and not one of tactics. But it is one which must be borne in mind, taking into consideration the character of the site and the soundings in its vicinity.

The action of the defence with regard to delay must be governed by the circumstances of the case; for example, by the strength of the enemy's fleet as compared with its own force, and by the probability of the arrival of reinforcements to either side; it may thus, possibly, be desirable to allow the attack to come at once to close quarters as soon as possible. In this case the mines would not be used for the purpose of delaying the enemy's advance, but with the object of refusing to him such portions of water as are the least efficiently swept by the fire of the guns, and also of limiting the extension of his line of fire.

Let us now pass on to consider—

IV. *The Principles of the Use of the various Portions of the Armament of a Coast Fortress.*

It will be convenient to divide these under the following heads, viz.:—

a. The guns.
b. The submarine mines.
c. The torpedoes.
d. Water defences: such as guard-boats, &c.
e. The electric light.

a. *The Guns.*

I have preferred to speak rather of the guns than of the forts or batteries, in order to lay stress upon a point which is too often lost sight of, namely, that the forts should be constructed to cover the guns, and not merely the guns used to arm the forts; by this I mean that the position for the guns should govern the construction of the fort, and not be governed by it.

It is probable that in future the artillery armament of a fortress will be divided into three parts, and that the design and mode of construction of the cover for each of these three fractions will differ essentially from those of that intended for the others; the site of this cover will also vary for each.

i. *The Heavy and Medium Guns intended for Direct Fire on the Enemy's Battle-ships.*—These guns will, wherever possible, be posted (the medium guns in batteries, the larger in separate emplacements) as high above the level of the sea as may be compatible with the power of commanding all water in their front which is of sufficient depth to allow of the passage of a battle-ship. The works designed to contain them form, as it were, the *enceinte* of the sea-front of the fortress, and it is upon their action, in the case of a systematic attack, that the ultimate success or failure of the defence depends.

It is most important that they should, as far as possible, be concealed from the enemy, or should be rendered to some extent invisible, either by the nature of the background, by the choice of site, or by their own colour and form; but, nevertheless, no portion of their offensive power should be sacrificed to the desire to obtain immunity from fire. These batteries are the true fighting-line, and must be prepared, both by construction and by armament, to resist a heavy and even a concentrated fire from the enemy. Great care will, above all, be needed in deciding upon the number, size, and position of their magazines.

Each of these forts or batteries should in action be an independent command, forming, as it were, a unit of the defence; and the conduct of the action in each individual work should be rendered easy by an organization and a system of command carefully laid down and practised during peace.

Either in or near each battery or fort a station must be provided for the commander and for such apparatus as he may need for con-

ducting the fire, whether this be a position-finder or a range-finder; this station should be rendered at least moderately secure from the fire of the enemy, either by concealment or by the construction of cover. It is evident that it should, when possible, be outside of the fort, both with the above object and, also, because otherwise the view of the commander will in many instances be interrupted by the smoke of the guns. It is further urgently necessary that the commander shall be supplied with some means of communicating instantaneously with each and all of the guns or sections of his command; without such communication the systematic conduct of fire is impossible.

ii. *The Guns or Howitzers which are intended for High-angle Fire.*—The positions for such guns may be selected within large limits, as it is not only unnecessary, but is in some cases even undesirable, that the enemy shall be visible from their site; they may thus be placed at any convenient spot which will enable them to make good use of their length of range. It will not in many cases (especially when the character of their position will permit their smoke to be invisible to the enemy) be necessary to construct any form of parapet in front of them, but it will be often most desirable to arrange for any necessary change of position by means of a tramway, the mountings being fitted with removable axles.

The object of their use is two-fold, viz.: to prevent the enemy from anchoring within their range, and to keep down the long-range bombarding fire of the attack; in each case they act by high-angle fire directed against the decks of the enemy's ships. There are two essentials to the efficiency of their action, an ample supply of ammunition, and a considerable number of guns. Though the high-angle fire of heavy howitzers has been found in practice to be exceedingly accurate in still weather, yet its efficiency must evidently suffer from many disturbing causes, owing to the low muzzle velocity of the shell. It is further necessary that its action shall partake somewhat of the nature of a surprise, for an enemy's ship which has received a bouquet of shell around her berth will probably move away as quickly as possible, and thus another sitting shot may not be possible; again, even with our improved system of directing fire, the effect of high-angle fire on a moving target cannot, if only on account of the time of flight, be confidently calculated upon. It is, therefore, necessary to make up for the comparative uncertainty of high-angle fire by the expenditure of a larger amount of ammunition.

It is absolutely necessary for the efficiency of these howitzers that steps shall be taken to ensure the most accurate observation of their fire, and for this purpose an observing station must be selected such that, while it is not conspicuous to the enemy, it may enable the fire of the guns to be easily watched; one station will be sufficient for a large number of guns, provided that it be supplied with means of immediate communication with every possible position of the guns. It may frequently be of advantage to use these guns by night for the purpose of annoying the enemy, or of driving him from his anchorage; in this case the range and bearing of the ships will generally be obtained by day.

It will be observed that, by the nature of their positions and to some extent of their armament, these guns will not be able to defend their front, and care must be taken that neither they nor indeed any of the advanced batteries are left undefended against the attacks of landing parties.

iii. *The Light Armament.*—This will include: 1. The movable armament, and 2. The armament intended for the defence of mine-fields and other obstacles.

Of the former I propose to say very little; it will generally be composed of field-guns, and will be used to aid in repulsing the attack of landing parties and also to assist in the defence of obstacles. It will further be probably employed on the land fronts of large fortresses.

The armament intended for the defence of mine-fields consists, I understand, principally of quick-firing guns; it will be well to consider the conditions under which these will be called upon to fight.

We may, I presume, assume that operations against mine-fields will rarely be attempted except by night, and that for preference a dark night will be selected, while every means will be taken to conceal and to cover the boats engaged in the work of destruction.

It appears, therefore, that these guns will have to fire on a small target, which will be moving with great rapidity, and of which all view will as far as practicable be denied to them. These are conditions of peculiar difficulty, and can be met only by adequate training and previous preparation. In theory it is, I presume, intended that the number of projectiles fired shall in some degree make up for the probable inaccuracy of the majority of them, and thus quick-firing guns are selected; but I may perhaps be pardoned if I add that I do not feel convinced that quick-firing guns are the best possible weapons for the defence of mine-fields.

But we have now only to consider how the fire of such guns can be made effective under the most unfavourable circumstances. In the first place we must, I think, lay down that their emplacements should be permanent, though the guns themselves need not be placed in position until they are required. Each emplacement, or mounting, should moreover be provided with some means of giving the necessary elevation without looking over the sights, and also with the means of giving the requisite training to each gun by some form of graduated arc. In addition to this, each emplacement should be provided with a plan of the mine-fields, showing the ranges and bearings of the various portions. It may by these means be possible to bring an effective fire to bear upon a totally invisible target, since the guns can thus be laid on any desired section, though the target *be* invisible.

I shall here be probably reminded of the existence of the electric light, but I would ask those of you who have seen it in action whether they have also observed the effect of—

1. The smoke of our own guns;

2. The smoke of the enemy's guns with a wind blowing on shore; and

3. Rays of light thrown by the enemy's ships either across our ray, or directly on the guns.

With regard to this last I am prepared to own that by so doing the enemy will enable us to lay our guns on his light, but to do so would answer his purpose and divert our fire from its principal object, the defence of the mine-fields.

Be this as it may, it is wiser to be prepared for the worst possible conditions, and to arrange that the power of vision, which may be out of the question, is not necessary.

Two other points yet remain for notice. First, it is desirable that the emplacements for the quick-firing guns shall be distinct, and even separate, from those of the main armament, both in order that they may not suffer from the fire directed on the latter, and also that they may be as far as possible rendered indistinguishable from the ships. They must, however, be at the same time so placed or so covered that they will not be liable to attack by landing-parties, for such an attack would, under many circumstances, be the best possible way of attracting the attention of the defence from operations against mine-fields.

Secondly, it is absolutely necessary that some system of communication shall be arranged between—

i. The guard-boats and the quick-firing batteries; and

ii. Between the observation parties of the submarine mines and the guard-boats;

for otherwise the presence of the latter may either paralyze that of the other two fractions, or they may, on the other hand, suffer by their premature action.

b. *The Submarine Mines.*

In touching upon these I feel that I am venturing upon rather delicate ground; with guns I am at home, but submarine mining is rather like a carefully preserved covert, from which trespassers, and above all, poachers, are rigidly excluded. I should not propose, even if I were fully competent, to go into any question of the technicalities of the branch, but rather to endeavour to suggest an answer to a question with regard to which I have up to the present been able to obtain no information. I do not venture to state that my solution of the problem is the correct one, but I wish to deliberately excite discussion, in order that the tactical, as distinguished from the technical, handling of submarine mines may be thoroughly ventilated.

My question is as follows: "Which is the auxiliary and which the principal arm; the guns or the mines?"

The answer which I propose is: "The guns are the principal, the mines the auxiliary, arm." For this I will give my reasons, merely premising that, to my mind, the entire system of coast defence rests upon the decision of this point.

These reasons are—

i. A system of defence which should depend upon guns alone is intelligible and possible, but not so one from which guns are excluded and mines only used.

ii. The defence of guns is active, that of mines passive.

iii. The destruction of mines is a matter of time; the silencing or destruction of guns requires something more.

iv. Guns are always ready; mines require careful preparation and constant care and renewal.

Observe also that mines have destructive power only so long as their existence is unknown: for we may, I think, assume that no enemy will in these days wilfully charge a mine-field. When mines are known to exist they fall into the character of obstacles, which cannot certainly be neglected, but can certainly be removed. From these facts (if facts they be) I venture to draw the conclusion that mines have two uses: (i) to delay the attack; and (ii) to deny particular areas to the enemy; serving thus either to keep, or to drive, the enemy under the guns; and further, that mine-fields which are not well under command of the guns are insignificant as obstacles, and cause but little loss of time to the attack.

From these statements I deduce the conclusion that the system of mine-defence should, in places where the gun-defence is already settled, be dependent upon the latter, while, where both are in embryo, they should go hand-in-hand, since those who fight the guns should certainly be consulted with regard to the position of the auxiliary defence. To do otherwise, and to work solely in connection with the soundings, is as if a man should in siege warfare make a mine at a certain spot, not because the mine was needed, but because the soil was suitable for mining.

I am inclined, therefore, to believe that the following should be the order of sequence:—

i. The main armament of guns; this to rule the

ii. Submarine mines; these to govern the

iii. Light armament.

c. *Torpedoes.*

These differ essentially in their nature from mines, in that they are not obstacles but projectiles, exactly as are shot and shell, except only that the medium through which they move is water and not air. The air torpedo, as fired by the pneumatic gun, forms, as it were, a connecting link between the two.

Following this line of argument, it would appear that torpedoes should be in the hands of those who have to do with all other projectiles, *i.e.*, of the Artillery; but, by some curious process of reasoning, they have been handed over to the Engineers.

If we regard the torpedo as a projectile, we shall find that it differs from the submarine mine by the fact that, like other projectiles, it cannot be rendered innocuous or abolished (as mines and other obstacles may be) before the commencement of the contest, but must be accepted and warded off. Torpedoes are, in fact, submarine artillery, though of low velocity and consequently limited range, and should thus be employed on principles similar to those which obtain with regard to the other projectiles of the defence, in comparison with which they have, however, one disadvantage, in that they cannot be

used for the defence of mine-fields, since their explosion n the same element would injure the very objects which they would be intended to protect.

I may perhaps draw attention here to the fact that torpedoes, both air and water, may be used for the destruction of mine-fields; the former will be especially valuable for this purpose, as their attack cannot be kept off by any obstructions, while their bursting-charge can apparently be almost indefinitely increased.

d. *Water Defences.*

Concerning these it will be necessary to say but little, since nothing can be decidedly laid down, either as to their organization or their use, as they will probably be extemporized, and will thus depend, both for their amount and that of their crews, upon the resources of the port or harbour. They will be practically the light troops, the outposts of the defence, preventing the action of corresponding forces of the enemy, and giving warning of any movement on his part. They will probably be provisionally armed in such a manner as may be found possible, but a certain proportion of steam launches must undoubtedly be provided.

Their duties will, as a rule, be discharged by night, and their main use will be to protect and watch the mine-fields, and to cover them from attack. Unless carefully handled and skilfully worked they will be very liable to hamper the artillery defence, and also that by mines, and should, I venture to suggest, be withdrawn before a systematic and determined attack on the mine-fields, while they should resist the action of isolated parties.

One great difficulty which will arise in connection with them is the question of their command; but this is, I think, capable of arrangement on the following principles:—

The defence of a coast fortress may be divided into—

i. The active defence, consisting of any ships which may be available for operations outside the harbour; these would of course be under the command of the senior naval Officer, acting in conjunction with, but independently of, the commander of the fortress; and

ii. The passive defence, which has been already partially described, and which should be under the command of the Officer commanding the fortress.

The water defence, as described above, falls under the passive defence, and should, I submit, be under the same command as the rest of that section; whether the Officer commanding the fortress should be a soldier or a sailor is, I believe, considered by some to be open to argument.

If this principle be accepted, it follows that, where the commander of the garrison is a soldier, it would be better not to employ naval Officers with the water defence, but to keep their services for use with the active defence; the guard-boats, &c., I should in that case propose to hand over to Officers of the merchant service, taking their crews from such of the population as were accustomed to the management of boats.

e. *The Electric Light.*

We are all acquainted with the use of the electric light, and I need not dwell on the advantage of being able to some extent to turn night into day, by employing it for illuminating mine-fields and targets of all kinds. But there are some difficulties connected with it on which a few words must be said.

The employment of the electric light is perfectly simple so long as it is a question, as it has generally been with us, of one gun (or one group of guns) and one light; but we shall find the matter very much more complicated if we endeavour to work out a system for the combination of the action of several forts and several lights.

I am inclined to think, on consideration, that the only plan to avoid difficulty is to allow a light to each unit, and to place it under the command of the commander of that unit. Nothing but confusion can result from the unconcerted employment of several lights by independent observers, who work neither in combination with each other nor with the guns, and are not connected with any other portion of the defence by any means of communication quicker than an orderly. I therefore venture to offer the following suggestions:—

i. Each fort or battery should be provided with a light.

ii. This light should not be posted in the battery, but at some distance to one flank; both in order that it may not be struck by shells aimed at the battery, or point out the position of the latter, and also because the beam of light itself is a disadvantage to anyone standing in rear of it.

iii. Wherever it may be, it must be under the orders of the Officer commanding the unit to which it belongs, and its movements must be directed by him alone; thus only can it be correctly used in real conjunction with the guns.

iv. There must be electrical communication between this Officer and the light. There would, I believe, be no difficulty, electrically speaking, in making an arrangement such that the light should be automatically moved, so as to throw a beam on any spot upon which the telescope of the Commanding Officer might be directed; but this would, of course, cost money.

v. It would probably be found convenient in practice to make a rule that no fort which is not engaged shall show its light.

As time goes by, and the use of the electric light becomes more general, it may be perfectly easy to provide a light for each fort, but this we cannot hope for at present; such lights as we have, should, therefore, I suggest, be especially told off to those batteries which are intended to defend the mine-fields.

I do not propose to enter here into any question of the technical working of the electric light, farther than to say that it should, as far as possible, be automatic, even down to the substitution of a fresh pair of carbons; but I do desire to draw attention to the necessity for the instruction of the Royal Artillery in its use, even though a complete equipment be not handed over to their charge.

The light is far more essential to guns than to mines, as the latter

signal automatically the approach of the enemy, while the former are useless in the dark; the guns and the light should therefore be in the same hands. Moreover, though we have every confidence in the skill and energy of the sister corps, whose motto is also "*Ubique*," yet we do not find that they are as ubiquitous as we; for example, there are twelve stations provided with artillery for coast defence, not one of which has a corresponding company of engineers. Something has already been done towards the object which I suggest, but more remains to do.

Balloons would probably be of great assistance, both by day and night, in directing and observing fire, and in generally assisting in the work of the defence.

V. *Further Details of the Tactics of the Attack by a Naval Force on a Coast Defence.*

Ports and harbours which are liable to attack from the sea may be roughly divided under three heads, viz.:—

i. Open roadsteads, from which a more or less narrow passage leads to the harbour proper; of this kind Alexandria affords a good example.

ii. Closed harbours with narrow entrances, such as Sydney or Portsmouth.

iii. Intermediate varieties, such as Plymouth or Cherbourg, where a naturally open harbour is artificially closed, but of which the outer line of defence practically presents the characteristics of the first kind.

i. (*a.*) It is evident that a long flat front of defence offers the greatest facilities to the attack from the sea, since it permits (to use a military term) of the deployment of the whole force, and of the consequent concentration of fire on individual forts, while at the same time it implies the comparative dispersion of the latter, with all its attendant disadvantages as regards unity of command and consequent unity of action.

It may be urged, on the other hand, that the fire-action of a fleet will, under such circumstances, be developed over a considerable length of coast, and will thus suffer as regards its intensity; but this disadvantage is more apparent than real, since it is not the whole coast, but merely a series of points on that coast, which must be overwhelmed with fire.

The action of the fleet against defences so situated will probably be somewhat as follows, assuming that an actual silencing of the forts and an eventual landing are desired.

1. The development of fire all along the front, carried out by ships detailed to each fort for this purpose; these ships to open a deliberate fire at a range beyond that at which their armour can be pierced by the guns of the defence, with a view to inflicting injury on the personnel of the forts, to destroy overhead cover, &c., and in such a manner as may retain the attention of the garrisons, and may at the same time diminish the resisting power of the works.

This fire should be delivered at comparatively long range, in order to take every advantage of the facility for searching cover which will be given by the high angle of descent.

2. The concentration of fire from certain selected ships on each of the forts in turn, beginning probably from a flank or, where the force of the assailant is far superior to that of the defenders, from both flanks. This fire to be delivered at decisive ranges, and to be directed as regards the heavy guns upon the armament, while the quick-firing and machine-guns will act against the personnel of the defence. Every endeavour will, of course, be made to enfilade one or more faces of each of the works attacked.

3. When the main armament of the forts has been silenced, the guns of the attack will be turned against the subsidiary armament; when this has been destroyed, the landing will be covered and supported by the use of quick-firing and machine-guns. If the attack be made from a flank, it may be possible to effect a landing on that flank as soon as the first fort is silenced; such action would tend to materially accelerate the capture of the others.

(*b.*) The consequent tactics of the defence.

The capability of defence of a position of this kind depends entirely upon the height of the forts above the sea, as it is governed rather by the power of resistance of individual forts than by any power of reciprocal support between them.

For example, if the batteries are in this case only a few feet above the level of the sea, the several works will be badly placed as to site for the purpose of independent resistance, while the fact that they lie as it were in a string, along the shore, prevents any possibility of satisfactory mutual assistance. Under such conditions all tactics will be useless owing to the original faults in the choice of site.

If, on the contrary, the forts, though on an extended line, have yet some considerable elevation above the sea, they will be comparatively secure from the enemy's fire (and above all from the dangers of enfilade fire), and may thus be able individually to cause so long a delay to the attack that neither time nor ammunition will suffice for their capture.

We may, I think, lay down as an axiom that—

Whenever, owing to the character of the site or from other causes, several ships can concentrate their fire on a single fort, while the latter, for similar reasons, can receive no assistance from the fire of collateral forts on the ships, the ultimate success of the latter is certain, and the excellence of construction, the weight of armament, and the other good qualities of the fort in question will, at the best, tend only to prolong the contest.

It is of course possible that, in many cases, such delay may be invaluable, but it then becomes a question whether the same results may not be obtained by other and less costly methods than building a fort.

ii. (*a.*) The attack of the entrance of a harbour, or of a channel leading to a harbour.

In this case the conditions which obtained in the last example are exactly reversed; it will probably be impossible to deploy the entire forces of the attack, and it will also, owing to want of space, be impossible to reinforce the ships which first engage, while their relief in case of need will be a difficult matter.

On the other hand, the fire of the forts will, as a rule, be converging, while the guns will have been so placed as to command the line of advance to which, as I have before pointed out, the ships will be bound. In other words, the initiative of the attack will be lost, for no such initiative remains to a commander who is compelled to attack through a defile. This advantage of the defence will, of course, be greater or less in proportion as the defile is more or less narrow.

It is possible that in certain cases the attack may commence by a bombardment at long ranges, directed either on the forts or on the establishments which they cover; but where time is limited, or ultimate capture is intended, such a bombardment will almost certainly be omitted, as causing delay and expenditure of ammunition.

The next phase will probably be the preparation of a passage through the mine-fields, while this again will be followed by the decisive attack. Of these the former will proceed on regular lines, which are already perfectly known, and into which there is no need for me to enter.

We may then pass on to the grand attack. A fleet which intends to bring matters to a crisis will move into decisive ranges; in other words, in its desire to inflict mortal injuries, it will advance to within armour-piercing distance of the forts, that is to say, to such a range that its own batteries will be liable to be penetrated by armour-piercing shell, while the remainder of the structure, above the belt, will suffer from common shell from large and perhaps from small guns.

I will next proceed, subject to correction from naval Officers, to endeavour to describe the probable course of this phase, merely premising that the decisive attack will almost certainly take place on the day immediately following the opening of a sufficient passage through the mine-fields, with the object of refusing time for any possible repairs or additions to the latter.

The ships will advanee in one or more columns, according to the width of the space available, and will move, as far as possible, directly on the forts, since the more direct the advance the greater will be the cover given by the leading ship to those which follow her.

On arriving within decisive range of the fort, the ships will change direction in succession and pass the fort broadside on in line ahead, each ship delivering her fire as her guns will bear, and concentrating from the first, all available action of quick-firing and machine-guns on the embrasures, ports, and gun-emplacements. This manœuvre will, of course, be limited to occasions when there is sufficient sea-room for its execution.

In other cases (and, indeed, I am inclined to think, whenever a quick decision is desired) the ships, having moved in, will anchor in

stations previously settled, using from thence the utmost weight of their fire upon the single fort whose capture may be for any reason deemed most desirable.

It may, perhaps, be well that I should here give my reasons for considering that ships which mean real work will anchor; they are :—

1. By so doing they will improve the accuracy of their fire, owing both to the cessation of movement and to the fact that the range will not change. The same may be said of the fire of the fort, but it is certain that the ships will have a numerical superiority in guns over any single fort, and the advantage to them will thus be greater than to their enemy, while the accuracy of their own fire will, as ever, prove the best possible safeguard against excessive loss by that of the enemy.

2. One of the ships, or perhaps more, will probably be able to take up a position where she will be out of reach of most of the guns of the fort (or of the collateral forts), whereas, when moving along the front, each ship will in turn pass the point on which the majority of the guns of the fort may with the greatest ease be concentrated.

3. Any station from which some part of the fort may be enfiladed will probably be so cramped, owing to its proximity to the shore, that movement in it will be dangerous, if not impossible; while it may happen, where the system of defence has not been well considered, that a ship may be able to place herself where she is defiladed from the high-angle fire of the defence by cliffs or other obstacles.

ii. The consequent tactics of the defence.

We may take it, I think, that in this case, as in all others connected with artillery, the main principle of the defence must be founded on the concentration of fire.

Fire will of necessity be concentrated on the leading ship as she heads the advance, and we may fairly hope that, since the direction of her length is extremely favourable to effect, she may be in some cases put out of action, or at any rate materially weakened, before she arrives at a decisive range. Since while she is advancing it will be almost impossible to injure her battery, and very improbable that we shall hit her water-line, our efforts must be directed to clearing her decks and tops, and to the destruction of her bows. With this object common shell should be used against her upper deck, and machine-guns should be directed on her tops. If she carries her heavy guns "en barbette," shrapnel burst well up will probably be the most effective projectile against them.

It is evident that in this practice the line will be of the greatest importance, and the guns should, therefore, when possible, be laid over the sights. If by good fortune the leading ship can be disabled while working through a narrow channel, it is obvious that a great check will be given to the attack, since it will be necessary to remove her in some way before the remaining ships can advance.

This species of fire will continue until the leading ship presents her broadside, and is in such a position that the majority of armour-piercing guns can bear on her.

The most favourable point for fire can be discovered beforehand by the Commander of the fort, and the guns should be ready, loaded with steel shell, by the time that she arrives at it. The requisite elevation can be easily given by means of the elevating arcs, and the concentration of fire can be ensured (if the matter have been taken in hand before the action) by allowing on the racers for the distance of any particular gun right or left of the gun of direction. The guns will be fired in salvo, if possible, at such a moment that the shell may strike the battery of the ship.

The medium and quick-firing guns will continue to fire at the unarmoured ends, unless the ship have barbette guns, in which case they will concentrate their attention on them and on the conning-tower. The machine-guns will fire in part at the tops, while some of them will be specially told off to fire on the barbettes, and others at the ports of the deck armament and battery. It will probably be well that a machine-gun should hold to one target throughout the passage of each ship.

The same process will be gone through as each ship in succession arrives in front of the fort, and the former tactics will be repeated against the stern of the last ship as she draws off.

Unless the interval between ships be very great, there will probably be time for no more than one round at each as she passes; and it will be as well, under ordinary circumstances, to limit the fire to this, in order that the guns may certainly be ready for each in turn. At least twice as many rounds as there are ships of the enemy should be at hand in the battery before the enemy's movement commences, half of these to be armour-piercing and half common or shrapnel shell, according to the orders of the Officer commanding.

As soon as the fire of any gun becomes ineffective, owing to the range or the angle at which the enemy has retired, every effort must be made to clear away all wreckage, and the dead and wounded, and to re-fit; fresh supplies of ammunition must be immediately brought up.

Should the enemy, either at once or at a later period, adopt the second form of attack suggested above, viz., the concentrated fire from anchored ships at decisive ranges, it will be for the Officer commanding the fort to order either the division of the total number of guns among the ships, or the concentration of fire upon each of them in turn. As a matter of principle it might be well to divide the light armament, and to keep the heavy in hand, so as to be able to throw its weight upon any ship from which the fire was especially annoying.

I would suggest the use of common or shrapnel shell against the unarmoured ends of all ships which are end-on to the work, and of fire against armour with steel shell only in cases where the broadside is fairly turned to the fort; an exception should, of course, be made when it is known that the armour of some particular ship is peculiarly thin. Should the Officer commanding the fort consider that he has frequently struck a certain space of the ship's armour, he may try the effect of a salvo of common shell laid on that point.

It is further evident that the collateral forts must use their best endeavours to assist the work which is first attacked, and they should do so with the larger proportion of their armament, paying comparatively little attention to the fire which is directed on themselves. The high-angle batteries, after ascertaining their range, should fire large salvoes, in order if possible to compel the enemy to shift his ground.

iii. The third case which I have mentioned will evidently require a combination of the two systems of attack which I have attempted to describe, and the modes of defence will be similar. It will therefore be necessary to make no further mention of it.

With regard to the whole of these questions, I would ask that what I have said should be considered rather in the light of an explanation of the principles of a suggested plan of defence, than as a strictly definite system for rigid application. We have at present no sufficient data upon which to found a detailed system of defence, and it has been my endeavour merely to offer for discussion a scheme so far connected that it is capable of being analyzed.

The plan of defence best suited to each fort will vary with its position and armament, as also with the manner in which it may be attacked; much of it must, therefore, be left to the inspiration of the moment, but we must, nevertheless, not forget that all preliminary arrangements must be worked out in time of peace, and that the garrison must be trained and practised in the details of all possible forms of action.

It may be considered that the system which I have suggested is too complicated for use under fire; it appears so only because we have too long held to the elementary principle of the independent working of individual guns—a principle which entirely prevents the possibility of concerted or united action—and have even as yet scarcely realized how necessary, in addition to mere drill, is a true war training.

I hasten, however, to acknowledge, and even to emphasize, the fact that the above system, or indeed any which will certainly ensure the concentration of fire, is only possible on condition that the organization and war training of coast forces, regular and auxiliary, shall continue to advance.

This leads me to remark that, lengthy as this paper is, I have barely succeeded in opening the subject of it, while I have of necessity been unable to say anything whatever with regard to an equally important matter, viz., the organization and training for coast defence.

Colonel E. T. THACKERAY, V.C., C.B., R.E.: With regard to the conditions referred to at the commencement of Colonel Walford's paper, I will just add one point that is perhaps not quite sufficiently impressed—I mean with regard to the new explosives. Colonel Walford has referred to the pneumatic gun. The Zalinski pneumatic gun, of which an account was read in this theatre on the 27th January, 1888, throws a shell containing 600 lbs. of blasting gelatine or 900 lbs. of gun-cotton with disabling effect on ships at a distance of 50 feet. What would be the effect upon ironclads of projectiles of such a description? We are often told that history

repeats itself. May I be allowed to refer to an incident that took place at Gibraltar in 1782, more than 100 years ago, when forty-seven sail of the line and ten battering ships attacked a fortress? The attacking squadron was composed of the French and the Spanish Fleets combined, assisted by land forces. On this occasion the efforts of the garrison were directed solely against the ships, and they paid no attention to the land fire. On the first day the flag-ship and two other ships were destroyed by fire, and on the following day three ships were burned to the water's edge. I only mention that fact in reference to the effects that may happen from the employment of the new explosives, and it may be similar to what occurred before, as shown from history. There is only one other point. Is it not probable that attacks on coast fortresses will take the form of a combined attack by land and sea? Such attacks were made by the French and Spaniards in 1782 at Gibraltar, by the French and Americans at Savannah in 1779, and at Minorca by the French and Spaniards in 1781.

Colonel Tulloch: Mr. Chairman, not being a naval Officer nor an artilleryman, I have considerable diffidence in saying anything with reference to the attacks of ships on forts; but, on looking over the history of attacks on shore batteries or forts, I think the general impression left on the mind is that the shore batteries, even in a small way, have generally got the best of it. You may remember specially the case of the attack on a battery in the Scheldt in the old French war, where the battery consisted of one 24-pounder howitzer, the result being that the French 80-gun ship had to withdraw with considerable loss, eighty or ninety men being killed and wounded. I merely mention this because Colonel Walford referred to the case of ships going in and attacking first-class fortresses. After the last experience we have had of iron ships attacking forts, we have found that even very indifferent forts can hold out a pretty considerable time; in fact, at our last experience, when it was all Lombard Street to a China orange, we took seven long hours before the orange was sucked dry. Now, in modern actions, where a heavy fire has to be kept up, the shells are very large indeed, and the ships will not hold any great number of them, and after a certain time the shells and the ammunition are used up. In former days you could engage a battery with plenty of ammunition and to spare; now it is not so; after a comparatively limited number of rounds your ammunition is gone. There is another thing with reference to the attack on forts. The smoke from the firing of the guns is so tremendous that it is almost impossible to see anything for a long time, and you have to cease firing, but the forts do not cease firing at the ships, whose lowest spars are always visible over the smoke as guides for firing on. I was the other day watching the French Toulon Fleet firing at a towing target. After a very few rounds from the big guns the ships had to shut up altogether on account of the smoke, but I particularly noticed that the most effective work was done by the smaller and less smoke-producing quick-firing guns, and the way in which they knocked up the water all round the target showed the immense value of this new species of armament. I do not propose saying anything more, as I merely wish to help on the discussion, and to show that in cases where ships have to attack forts they will, if possible, avoid doing so; more especially if there should be any hostile ships anywhere in their vicinity which might suddenly attack the bombarding ships with their nearly empty magazines.

Admiral Colomb: It is said that when epidemic diseases arise where there are negroes, the negroes are much more likely to be affected by those diseases than white people, and that if they are affected there is great difficulty in keeping them alive, because they have so concentrated their minds on the preparations for dying. Now, I cannot help remarking that it is somewhat the same with us at the present time, that our attention is so very much turned to this preparation for Imperial dying. We have had a lecture to-day which directs our study chiefly to conditions when the Empire is at least moribund, because the necessity for the defences that we have heard spoken of, cannot arise until the Empire is so. But the lecturer has redeemed his case a good deal, because he has given us rather more of the tactics of attack than of the tactics of defence, and for that I commend him. I do not feel that in this case he is wrong in treading on naval ground, in putting forward what his views may be of the tactics of naval attack of fortresses, because it is a matter which should engage the military mind as much as the naval mind. So far as I

know, there will be very little pure naval attack by us on any fortress. I quite agree with what Colonel Tulloch said, that we cannot do much in attack by purely naval means. I think the lecturer has laid a great deal more stress on what ships can do against forts than naval Officers would use as a rule. I think our feeling is, judging from the past, that we must have in nearly all attacks that we make on territory, not only the assistance of the sister Service, but that the main part of the business will be in the hands of the sister Service, only assisted by the Navy. Then as to the conditions under which the attack can be made. I am glad to note how the lecturer has pointed out that to make a territorial attack you require a free sea behind you, for at least a time; but I do not think he has laid sufficient stress upon that. I think we in the Navy are coming quite to a clear conclusion now that, except for the throwing of a few shells by way of insult by a single cruizer, and that sort of thing, no territorial attack can take place unless the enemy has an absolutely free sea behind him, and I think in dwelling upon the nature of the obstacles, and especially submarine mines, he is right to show that the attack by ships on territory, on fortresses, on harbours, and so on, is removed one stage further off. I think that the general condition of opinion is, in the Navy, that on the whole the advantage as against the Navy remains with the fort—that is to say, that less fort will now be more effective than more fort was in the good old days of war. In speaking of surprises and cutting out, those are matters which really do not affect the tactics of either attack or defence, because they are in the nature of surprises, sudden businesses which it is impossible to prepare for, which are done, as the lecturer said, in a dark night, suddenly; therefore, I do not think you can treat them in the general way at all; each case must be taken separately. As regards forcing passages, I am sorry the lecturer should have thrown aside so readily the experience of the American Civil War. In all these cases I do not think we can go beyond the experience that is before us, and I cannot admit for one moment that the experience of the Americans in the Civil War is obsolete. I think we should apply ourselves to the study of what was done by the American Navy in those cases. What seems clear from American experience is that the forcing of a passage past forts is a comparatively easy matter if there are no obstacles to be encountered, but that it is an exceedingly difficult matter to force a passage if the ships are to be delayed under the guns in trying to force that passage, and the great power of the submarine mine seems to me to be that it will do that. But then what happens? It throws the ships again still further back, and makes the difficulty of these passages greater still, and points out that if you are called upon to pass forts you will have to settle down regularly with the sister Service and possess yourself of the forts and of the mines too before you attempt to make your passage. As to bombardments from a distance, I think that there would be unquestionably for a superior naval force—for the nation which had the free sea—a considerable amount of that sort of thing. I should expect a great deal more than there used to be, although there always was much of it; but in speaking of the fire of ships upon places as distant bombardment and the return fire of forts upon the ships, I think the lecturer has imagined the fire will be lighter than it really will be. I think we should not undertake the bombardment at all unless the target was a pretty good one, and we should fire pretty well for the centre of the target and do as much damage as we could, not being very nice as to whether we wanted to possess ourselves of the place afterwards and make use of it. So also with the tactics of defence. I am sure that as far as our gunnery goes in the Navy we should try to hit the centre of the ship, and I do not know that we could go very much closer into it. I think under the circumstances, unless the conditions were very exceptional, we should simply content ourselves with hitting the ship, and as nearly in the middle as possible. We should fire at the middle as being most likely to hit her somewhere, and I suspect that that would be the case also with forts. I think the lecturer used a golden expression when he pointed out to us that the forts should be fitted to the guns, rather than that the guns should be made to fit the forts. I myself have long had the impression, which I presume is shared in by the lecturer, that there is a slight tendency to suppose that the gun is the secondary business, and that if you get the fort right the gun can be easily fitted to it afterwards. I was struck, having had no experience beyond what I have read about range and position-finding, by the lecturer's remarks upon that question;

they did not seem to bear out what I had generally read about it. He seems to throw some doubt on it, and to say that there are more difficulties in carrying out range and position finding than we had at first imagined. For instance, the smoke passing before the Commander directing the fire of, I presume, many batteries, seems rather awkward, for it is possible that that smoke might interfere with the whole of the fire of the batteries under his control. Also, I am very glad to think that the lecturer has put submarine mines in what I believe is their proper place, as an auxiliary. I fully agree with him that the heavy guns must come first of all—first the heavy guns if you wish to defend a place by heavy guns. Then the mines must come, simply with the object of detaining the ships under the fire of the guns; and thirdly you must have the light guns, and their position must be entirely determined by the position of the mine-field. But there is this always to be borne in mind, that a little mine for ships goes a very long way, that the mere fear of mines—recollecting that you have valuable ships under your feet—the mere fear of losing those ships on the top of those wretched mines will keep you very much off, and therefore you need not suppose that you require anything particularly elaborate. I believe if you were to poll the Navy now it would be said that we should never go into shallow water unless we first ascertained that there were no mines there. That is the first thing to be done. We do not now trust to chance, not so much on account of the danger, but on account of the waste of money it is to lose a ship on the top of a submarine mine. I think the lecturer has struck oil in pointing out—I am not sure that I have heard it before—how effective the locomotive torpedo may be in destroying mine-fields. It may be simply that the thing is newer to me, but I have not that I am aware of heard it distinctly suggested that locomotive torpedoes should be used in that way, but I cannot help thinking that it might be very effective. No doubt the lecturer does not mean it, but the paper reads as if he thought net defence was a defence against some sort of fixed mines, but it is no such defence. No ship would use net defence passing a field of fixed submarine mines of any sort: it is only a defence against locomotive torpedoes, because, as a matter of fact, the net does not cover the bottom: it covers the side only. I think we may say that anchoring depends on the conditions of the case. You would anchor if you found you were not being hit, but if you found you were being hit there would be no anchoring; you would trust to the size of the target you were firing at, and give up the accuracy that you could get by anchoring. I do not think you could lay down any rule about it. The lecturer seems to me to speak truly in declaring that ships will not recklessly charge mine-fields. Although Farragut did it, using the now historical words, "Damn the torpedoes"—although they reported that the "Tecumseh" had just gone down ahead of him, he said, "Damn the torpedoes, full speed ahead." He did it this once undoubtedly, but I question whether we should in any case wilfully charge a mine-field, unless the object to be attained was immensely important and you did not mind losing a ship or two in endeavouring to gain it.

Major Walker, R.E.: There are a very few words I would like to say with reference to some points in this paper, especially after the very able manner in which Admiral Colomb has discussed it, which has left very little for me to add. There is one statement that I think needs some qualification; the lecturer says: "The arrangement of the defence in such a manner that no fort can be exposed singly to such an attack is, of course, a question of construction in time of peace, and not one of tactics." Now, I think that shows a total misconception of what fortification is. I think that fortification is tactics; you cannot separate fortifications of any kind from tactics. The lecturer says that himself where he states that "a considerable number among us still regard the tactics of coast defence as being a contradiction in terms, owing to the fact that no movement of troops is possible under the conditions of the defensive action of forts." Then he says the idea of movements which has been held necessary as a distinctive feature of tactics is not necessarily a condition of tactics; the mere fact of the forts being immovable does not alter the case in the least; it is just as much a question of tactics in placing your forts beforehand to defend the Channel as it is a question of tactics on the part of the Admiral of the attacking fleet how to arrange the ships for the attack; both things are equally tactics. I think it is absurd to say you can in any way

dissociate fortifications and tactics; all fortification is tactics, nothing more. It is a very common error, I think, to say that fortification is the art of construction, and I am afraid it is a very prevalent error to think that engineering and fortification are synonymous terms. I deny that altogether. In order to build a good fort a man must have (if it is an elaborate construction of iron and stone, such as we have had in times past, but are not likely to have again soon), to erect a construction of that kind successfully, a knowledge of engineering, but he need not have any knowledge of fortification at all. It is merely a question of engineering, and we are too liable to confuse that with fortification, and to confound the two things. Fortification is tactics, and the soul of fortification is the knowledge of tactics, and unless people who design fortifications are acquainted with the tactics of defence and attack they will design bad fortifications, and if the fortifications are good they will have effects, no matter how badly they may be built, within limits. But the questions of building, and of fortification proper—the real soul of the science—are quite distinct, and it is a very great mistake to confuse them. I do not think that is very commonly acknowledged. I have heard it said very lately that there is no special knowledge of fortification possible, everybody is equally well acquainted with the subject; but I think fortification is a science which requires a great deal of study, and for that very reason, that it is tactics, and that it is continually changing in consequence. It is founded upon the arms in use, and unless the men who design fortifications are acquainted with the progress of military science generally they will design bad fortifications. That is the first point I want to draw attention to. Then there is another part of the lecture in which Colonel Walford lays down that "whenever, owing to the character of the site, or from other causes, several ships can concentrate their fire on a single fort, whiie the latter, for similar reasons, can receive no assistance from the fire of collateral forts on the ships, the ultimate success of the latter is certain." I think I agree with Admiral Colomb, that a little fort often goes a long way, and if you take the instance of Fort Fisher, in the American War, you will find there it is not so certain that, even with a powerful squadron all firing upon a single, very weak fort, you will get this very decisive result. What happened at Fort Fisher? They attacked it on two days in December, two successive days: the work was attacked by a very large fleet. On the first occasion they poured in—I am speaking from memory, but I think I am right in saying that the official despatch gives the number as—115 shells per minute for four hours, and on the second day the same fleet went in again and attacked the fort, and poured in 50,000 shells in the space of seven hours. What was the result? The official report made to General Butler was to the effect that the fort was practically uninjured as a defensive work. That shows that the power even of concentrating a very large fire on a single fort does not mean immediately such very decisive results as that paragraph would lead us to suppose, when the fort is efficiently constructed. In that case, though it was a poorly constructed fort, it was efficient for its object, because it was a fort constructed of sand. There is again a question that Colonel Walford asked about the proper place of submarine mines, and he lays down, I think, absolutely correctly the relative importance of guns and mines. He says he asks the question because he has not, up to the present, been able to obtain any information, and he states his conclusion to be, first in importance, the heavy guns, then the mines, then the light guns. I do not think that there has ever been any doubt on that subject, as far as I know. It is admitted by all experts in fortification that submarine mines are only an auxiliary defence. Surely nobody ever imagined that submarine mines alone should be made a detence. I certainly have never seen it. There is one little point as to the attack on submarine mines by torpedoes that, I think, is perhaps worthy of notice. I believe the Zalinski pneumatic gun is looked upon as being likely to give very efficient results in that way; the launching of large charges by that gun, which explode under water, will be a very efficient means of attacking such mines. There is one other little point that Admiral Colomb mentions that I might say a word about, and that is with reference to position-finding. There is very little said about it in the paper; but as to the difficulty about the smoke, I think it is hardly generally understood how little difficulty there is in that particular; efficient position-finding, as we now understand it, will really be conducted at such a distance from the guns that the smoke does not, as a rule, come in

at all. There are particular cases, no doubt, where owing to the difficulties of site the position-finders will have to be in the immediate neighbourhood of guns, but this will be the exception rather than the rule, and I believe, as a rule, the smoke difficulty, which has been mentioned more than once lately in this theatre, will not play any important part in position-finding, and I think it is an undoubted fact that the introduction of position-finding has made a most enormous difference in the question of the possibility of land forts being attacked by ships—a difference altogether in favour of the land forts.

Colonel HAMILTON TOVEY, R.E.: I first of all wish to thank Colonel Walford for his very interesting lecture. As an engineer, I feel especially grateful when we have an opportunity of hearing the opinions of other Officers, and especially of naval and artillery Officers, on this question of the fortifications which it is our duty as engineers to construct. As to the criticisms that Colonel Walford has made as to the position of existing forts, I really think that, considering the changes that have taken place in circumstances, and especially in the arms in use, since these situations were selected, the existing forts cannot be said to have been badly placed at the time when they were built. I think that criticism on this point very often goes too far; it does not allow sufficiently for the fact that the position of sea forts is dictated to a very large extent by the nature of the channel they have to defend. For instance, we hear it constantly said now, and I have heard it said here recently by Officers of my own branch of the Service, that earthworks are now everything, and that it is now quite out of the question to think of building forts of masonry or iron. Now it is obvious that in some situations it is impossible to build earthworks—for instance, at Spithead, or upon any rock or cramped position in the centre of a channel, or any very circumscribed position where it is necessary to mount heavy guns. The only way of providing guns for such a position is to put them in a very concentrated form, and if we had to do that now we should still have, as in the past, to build iron forts. There is another point which I notice in Colonel Walford's lecture. He dwells upon the necessity for placing guns a considerable distance above the water. Now in some situations you cannot do this; for instance, at Portsmouth, where the coast line is only a few feet above the water in the greater part of its extent. With regard to the special part of the lecture to which I would call attention, my hands have been very much strengthened by what Admiral Colomb has said. I have thought over the question a good deal, and I must say I have come to the same conclusion which I understand the Admiral has arrived at, viz., that the attack upon forts by ships will be so very dangerous and difficult, that if the attacking force can possibly avoid direct attack, they will do so. Admiral Colomb suggested that it is almost impossible that our harbours and forts should ever be attacked by an enemy, on account of our always having a superior naval force. Admiral Colomb has lectured on that subject lately, and the discussion has made it very clear that we do not all agree on that point. Many distinguished Officers, naval as well as military, think it by no means an impossibility that our harbours should be attacked. Nevertheless, I am very glad to agree with Admiral Colomb's suggestion, that the question is one which should not be looked upon entirely on one side; we must also consider it as it will affect us when attacking the forts and harbours of our enemies, which appears to me will most certainly be a phase of any war in which we shall be engaged. Looking back to history, we find a great many instances of attacks by British forces on foreign possessions, and in nearly all such cases the attack has been carried out in the way that Admiral Colomb suggests, *i.e.*, by a joint expedition, by the Navy assisted by a large military force, and I cannot help thinking that that is the real kind of attack which is likely to take place, whether on our own forts or by ourselves on the forts of our enemies. This point has, I think, been too much overlooked by our own people in the construction of our most recent fortifications. It may be quite right in defending a harbour to concentrate your strength in the direct channels of approach, to multiply your batteries, and to spread your guns, but I think it is not sufficiently kept in mind that if an enemy has to attack such a harbour, they will not run their heads against such strong defences, if they can possibly avoid it; but if they can land a force along the coast and outflank the defences by an attack in rear, they will certainly do so. If they succeed in doing this, these detached batteries, isolated and

with small power of defence, will very soon fall from blockade, assuming, as we must, that the attacking force will be superior in number to the garrison. That is a special point to which I wished to call attention, the necessity for a strong centre of defence. I would especially thank Colonel Walford for advocating the practising of the offensive and defensive tactics of coast defence in time of peace; there are so many points respecting these tactics which are so utterly unsettled, so difficult to see the exact way to carry it out, and these are impossible to be solved without actual practice in time of peace. I may instance the questions of unity of command, of the organization of forces, of the use of guard-boats in connection with batteries—the latter certainly a point that wants very closely going into—for unless some very definite rule can be laid down, the position of guard-boats in front of batteries during an attack will be a very uncomfortable one. Then there is the absolute necessity for more electrical communication between the forts and between the mine-fields and the central command. Then the question as to the number of electric lights, both for mine-fields and for batteries. All these things require a great deal of care, and although they cannot, for pecuniary reasons, be all supplied at once, we ought to have very definite and exact ideas of what is required, and how it is to be obtained.

Major-General DUNNE, Commanding Chatham District: I think it is to be regretted extremely that the Inspector-General of Fortifications and all his Staff, and also nearly the whole of the Submarine Miners of the Royal Engineers, are engaged at Chatham to-day, and consequently they are deprived of what, I think, will be of great use, *i.e.*, the valuable remarks that have been made on the subject of submarine mining; and we, too, may have lost the benefit of their criticisms on Colonel Walford's paper, in which he may have a little too much minimized the power of submarine mines, while, on the other hand, perhaps Admiral Colomb rather exaggerated their power. I rise merely to say that I think the subject of the lecture would have been better thrashed out if we had had some of the able representatives of the submarine mining party here to-day. I do not myself feel inclined at this late hour to take up the question, especially as I am not a submarine miner.

Colonel WALFORD, in reply: I think the principal remark I have to make is that it has been said that I have passed over some few matters very lightly, while I have not mentioned others at all. I should wish on this matter to draw your attention to the fact that the paper is already too long. I am allowed to speak for only an hour, and I began my paper (and I think I also ended it) by saying I could do nothing more than merely touch on a few introductory points. No one is more anxious than I am that the subject should be ventilated. I believe that no attempt has ever up to the present time been made to do so, and I have read my paper to-day in the hope that, the subject having been once introduced, some one might be tempted to take it up and work it out thoroughly. Admiral Colomb said he thought such tactics of coast defence would not come into practical use until the Empire was moribund; but, I think, a good many artillerymen, now stationed in various Colonies, will feel that we may very possibly be called upon to fight single ships, or small squadrons, even if a combat with a large fleet be out of the question. As to cutting-out tactics, I had time to say no more than they were considerably complicated by the electric light and submarine mines. Admiral Colomb said he thought that we on shore would be content to hit a ship, and would not lay on any special part of that ship. I do not agree with him. My own impression is, and I believe most gunners would agree, that as soon as a ship anchors, and we get a standing target, we shall aim at the heart of the ship, and not at the ship as a whole. As long as the ship is on the move, I think we should attempt no such nicety, but should merely strive to hit the ship somewhere. With regard to the question of torpedo nets, I was aware that net defence was not intended to be used against submarine mines, but I had no other way of expressing what I meant. Possibly it may be in your remembrance that during the war in America some of the ships were rigged out with temporary expedients for clearing away submarine mines, a framework of some kind in front of the bows; it was this to which I wished to refer. Major Walker made what appears to me rather a large statement with regard to the relative positions of fortification and tactics. I

should prefer to say that fortification should be included in tactics, and is perhaps rather a small part of it. I am inclined to think that tactics are so very much larger in their scope than fortification, that it would be more correct to describe fortification as one chapter of tactics.

Major WALKER: I said the soul of fortification was tactics.

Colonel WALFORD: Again, with regard to the position-finder, Major Walker said that in the stations now provided for the position-finders, there would be no question of interruption of the view of the Commanding Officer by smoke. With this I entirely agree; but I know also many forts where the station provided for the Commanding Officer is absolutely useless, and so dangerous that you would have to provide six or eight reliefs of Commanding Officers. I can call to mind one or two stations where a Commanding Officer would not have a chance of living five minutes under fire, and whence he certainly could not conduct the action at all. I have further only to thank you for your kind attention.

The CHAIRMAN: Gentlemen, I have no intention of entering into any controversy, but as regards one point, whether it is necessary for us to be, or to wait till we are, a moribund Empire, in order to discuss this subject, I am afraid I can hardly agree with Admiral Colomb. I have the honour to serve on the Colonial Defence Committee, and on that Committee I have the priceless advantage of having as one of my colleagues the Director of Naval Intelligence. Before we discuss a question of local defence of any particular point, we, as a rule, have a memorandum drawn up by him as to the nature of naval attack to which this place is liable, and where the matter is at all serious we get the Admiralty's concurrence with that memorandum. So that we have the authoritative statement before us, not only that these places are liable to attack, but that they are liable to a particular nature of attack. Therefore, it seems to me, when we have got to the point where we have an agreement between the Admiralty and the War Office that it is necessary that certain places should be fortified against an attack of an enemy's ships, the one thing above all things we have next to do is to learn how we ought to defend them; and that, I think, is what we are immensely indebted to Colonel Walford to-day for helping us to study. There are one or two points I would say a word upon. First, as to the question of bombardment at long ranges. Personally I attach very little importance to it, except to its moral effect. I do not believe in it; and in the instructions which were sent out two or three years ago from the War Office to all the General Officers commanding fortresses at home and abroad, directing them to prepare complete schemes of defence, each one of his own fortress, it was particularly pointed out that the effect of bombardment was in nearly every case more moral than actual upon the public, and that if good arrangements were made for putting out fires, which have been organized in these stations as far as possible in times of peace, no place need submit to pay a forced contribution simply because it is threatened with bombardment at long range. The question of combined attack by land and sea is a very important one. We consider in dealing with the defence of different places that there are different classes of attack: there is the attack by a single cruizer, there is that which the Admiralty recognize as an attack by a small force of cruizers able only to land such parties as they could lend from their crews, and that would be a limited number, a very small number, perhaps 200, 300, or 400 men. Then, directly we get beyond that, we come to the fact that if serious attack is to be made upon any place, it must be made by a combined force of troops and ships, and that means that the naval force going to attack this place must convoy transports; and I agree with Admiral Colomb that this means having command of the sea, or else it can only be an operation attempted immediately upon the very outbreak of a war from a port very close to the one to be attacked, a risk which might be run for the sake of capturing or destroying a coaling station before a superior hostile fleet could intercept the operation, and that I think is a risk fully recognized at the Admiralty. As to the question of smoke, whether we are ever going to get this smokeless powder it really is difficult to say. I believe great advances are being made in that direction, and if we get a thoroughly good smokeless powder, that will give another additional advantage to the position-finder. But I must say myself I look forward to something beyond the present position-finder. I look forward to this with confidence, and with the most absolute belief and conviction in my mind that at a day not far

distant we are going to have it. I look forward to the time when the motion of the telescope of the position-finder will not merely move hands on a dial in the battery, leaving many elements of human error in existence, such as reading the dial and laying the gun, but when the motion of the telescope will lay the gun directly upon the object. That we shall come to that I have not the slightest doubt. Major Watkin is as convinced that he will arrive at that as I am that he will. When we arrive at that it does seem to me that the fort will have an immense and overwhelming advantage over the ship. We have not got to it yet, but I firmly believe that we shall. There is only one thing more to which I think this lecture points, and points with great force, and that is to the absolute necessity of close co-operation, not only in the study of these subjects, but in the carrying of them out, in the first place between the Artillery and the Engineers, and in the next place between the Army and the Navy. There are naturally (I hardly like to use the word) jealousies, but there are naturally slight conflicting feelings, each, in fact, saying, "There is nothing like leather," and that leads to a very slight feeling of jealousy. The artillerymen may think that they ought to have the electric light and the torpedoes; the engineers may think these are best in their hands; the control of the guard-boats and questions of responsibility for active and passive defence may not be yet thoroughly settled as they ought to be between the Army and Navy, and therefore I venture to think we want some body brought together to discuss these questions, with one heart and one object, the sole object being to decide, not what is best for the Army or the Navy or the Engineers or the Artillery, but what is best for the country; a body able to discuss these matters authoritatively and closely, and to arrive at a clear authoritative system of tactics to which all soldiers and sailors, artillerymen and engineers, ought to work. With these words I will only say I hope I shall carry you with me when I ask you to give a most sincere vote of thanks to Colonel Walford for bringing before us this subject in such an able way—a subject which is more interesting to our nation than perhaps to any other, because we of all nations have the largest sea-board to defend. As Colonel Walford tells us he has only touched on the fringe of this subject, I think you will perhaps agree with me, it would be an excellent thing if he would continue it in another paper at some future time.

Friday, May 31, 1889.

ADMIRAL H. BOYS, Vice-Chairman of the Council, in the Chair.

ON THE MARINER'S COMPASS IN MODERN VESSELS OF WAR.

By Staff-Commander E. W. CREAK, R.N., F.R.S., Superintendent of Compasses at the Admiralty.

IT is now seventeen years since the late Captain Sir F. Evans gave his last lecture in this Institution, on the magnetism of iron ships and the treatment of their compasses. It is true that during that period the improvement of the mariner's compass as an instrument of navigation and the means of correcting its errors have been the subject of various papers, but there remains much to be said on the increasing difficulties with which the compass on board modern ships of war is surrounded, and how those difficulties have to be met and overcome.

The Council of this Institution have done me the honour of inviting me to read a paper on this subject, and I have therefore prepared the following remarks commencing from the period of 1872, and in continuation of the paper before referred to. There will, consequently, be no need to enter into the historical portion of the subject, as it has already been so fully treated of in several papers written in England, and also in that excellent introduction to the French translation of the Admiralty Manual of 1870, entitled "Exposé Historique," by Lieutenant Collet of the French Navy.

In addressing an audience of my countrymen I need hardly make an effort to arouse a special interest in the subject of the compass in ships-of-war. We should know now—if not from our own conception of what is needful to the national safety—at any rate from the writings and speeches of numerous high authorities, both political and naval, that we must have a large and powerful navy, one part of it consisting of vessels possessing considerable powers of resistance to the effects of modern projectiles combined with high speed; the other part, a more numerous family of small lightly constructed craft of still greater speed and handiness.

This consideration of high speed points to the necessity of providing our ships with compasses of the greatest accuracy with which to navigate them, capable of withstanding severe vibrations of the hull caused by their powerful engines, and shocks from firing heavy guns, while the requirements of a modern war vessel as regards dis-

tribution of the iron and steel armour seem to vie with the previous considerations in rendering the task more and more one of care and judicious treatment. Let us therefore inquire into the various causes of disturbance, mechanical as well as magnetical, and ascertain how far success has been attained in making the compass, in the midst of its numerous enemies, the instrument of precision we would fain have it.

Referring to the paper of 1872, it will be found that after an examination of the magnetic history of a large number of iron vessels of the Fleet combined with the results obtained by the Liverpool Compass Committee, certain definite conclusions were arrived at of which the following are the principal:—

"1. The magnetism of iron ships is distributed according to precise and well determined laws.

"2. That a definite magnetic character is impressed on every iron ship whilst on the building-slip, which is never afterwards entirely lost.

"3. That in an iron-built ship and in that part of her within which the navigating or standard compass is generally placed, the polar force is that from the magnetism of the whole body of the ship, and is nearly uniform; that we cannot escape from the action of that force by any care in the selection of a place for the compass.

"4. That the definite magnetic character of an iron ship, so far as relates to the polar forces developed in her during construction, is shown by the connection which exists between the direction of the ship's original magnetism and the direction of her head when on the building-slip; for the original semicircular deviation consists principally in an attraction of the north point of the compass-needle to the part of the ship that was south (or nearly so) in building.

"5. That a great reduction takes place in the magnetism of an iron ship on first changing her position after launching, and that her magnetism is then unstable for a short period. Then, after a few months' service, perhaps within a year for the average of ships, the time probably depending on the nature of the iron employed in the construction, the magnetism of the ship acquires a very stable character.

"6. That in iron-built ships, as at present constructed, the ship's polar force is generally so great as to make it necessary to employ magnets to equalize the directive force on different azimuths of the ship's head, even at the most carefully selected position."

Of these the two first conclusions have been fully confirmed by observation up to the present time. Of Nos. 3 and 4 it may be said that they are only so far true, "that we cannot escape from the action of that force (the polar force of the ship) by any care in the selection of a place for the compass;" but however carefully the position of the standard compass may be selected in modern ships, it is very seldom that the polar force at that position "is that from the magnetism of the whole body of the ship." Not many years ago it was a matter of simple calculation to ascertain approximately the direction in which a ship had been built, if the deviation on two adjacent

cardinal points of the compass were known, showing that the compass was affected by the whole body of the ship. Now, however, from the largely increased use of iron and steel in the shape of superstructures in turret-ships, conning-towers, iron masts, and deck cabins, the deviations observed at a standard position proceed from the hull largely dominated by that of the nearest iron body. For example, the turret-ship "Hecate" was built with her head in a northerly direction, and, according to conclusions 3 and 4, the standard compass needle should have been attracted towards the stern. It was nevertheless attracted towards the bow by a force greatly in excess of the earth's directive force. Again, in the "Dreadnought," built head S.W., the attraction should have been towards the port bow; whereas it was found acting strongly towards the stern, and, as in the former case, by a force greatly in excess of that of the earth. Conclusion 5 may be considered as confirmed by the experience of later years to a great extent, but really before a ship is commissioned she undergoes such lengthened trials under steam at high speed, followed by gun trials, that she may be expected to have assumed a fairly stable magnetic condition, and subsequent changes will occur very slowly, forming no source of anxiety to the navigator.

The following conclusions are the results of a comparatively recent investigation of the deviations of the compass at the standard positions of a number of vessels of different types, which had during their commission traversed large ranges of magnetic latitude during the years 1871–83, and amply confirmed by subsequent results up to the present date.[1] The list includes six armour-plated vessels, four of iron cased with wood, three iron troopships, three iron and steel cased with wood, and seven composite-built vessels. The deviations were not only analyzed according to the usual methods by which the several values of the semicircular and quadrantal components are ascertained, but the semicircular deviations were subjected to a further analysis, showing how much was due to hard and soft iron, or to iron of a character intermediate between what is known, magnetically speaking, as "hard" and "soft" iron. Always remembering that the observations were made at standard positions carefully selected as the best available in each ship, the following conclusions were arrived at:—

"1. A large proportion of the semicircular deviation is due to permanent magnetism in hard iron."

"2. A large proportion of the semicircular deviation may be reduced to zero, or corrected for all magnetic latitudes, by fixing a hard steel bar magnet or magnets in the compass pillar in opposition to, and of equal force to, the forces producing that deviation."

"3. A very small proportion of the semicircular deviation is due to sub-permanent magnetism, which diminishes slowly by lapse of time."

"4. The sub-permanent magnetism produces deviation in the same direction as the permanent magnetism in hard iron, except when temporarily disturbed, (1) by the ship's remaining in a constant position

[1] See "Phil. Trans. Roy. Soc.," 1883, Part II, p. 615, *et seq.*

with respect to the magnetic meridian for several days, (2) by concussions, (3) or by both combined, when the disturbance is intensified."

"5. To ascertain the full values of the changes in the sub-permanent magnetism, observations should be taken immediately on removal of the inducing cause."

"6. In the usual place of the standard compass, the deviation caused by transient vertical induction in soft iron is small, and of the same value (nearly) for ships of similar construction."

"7. The preceding conclusions point to the conditions which should govern the selection of a suitable position for the standard compass with regard to surrounding iron in the ship."

Now the establishment of conclusions 1 and 2 was very important, for it showed that the principal part of the magnetism of armour-plated ships like the ordinary iron ship was nearly all permanent, and could be corrected once for all by permanent magnets, instead of "the amount of the induced and permanent magnetism" being "nearly equal," as was supposed in 1872—conditions which would have necessitated either the acceptance of a constantly changing deviation as the ship proceeded from high to low magnetic dip in one hemisphere, and *vice versâ*, or the constant alteration of the correcting magnets as well as the application of a large Flinders' bar. One instance of the latter complicated state of things in the case of a Sir William Thomson's compass, placed, for convenience of handling the ship, forward, abaft the director-room of the "Agamemnon," may serve to illustrate. When that vessel proceeded from Colombo to the Mediterranean, although 4 feet of Flinders' bar were fixed to the binnacle, the magnets required to be constantly changed to keep the compass errors within moderate limits. Here the changing part of the semicircular deviation due to vertical induction in vertical soft iron, varying as the tangent of the dip, was largely in excess of that due to hard iron. On the other hand, the "Impérieuse" has been to the Cape and then to Hong Kong with less change than many an old wooden ship.

Conclusions 3, 4, and 5 may be discussed together, as they all refer to the sub-permanent magnetism of the ships. But first let us pause to consider for a moment the exact definition of sub-permanent magnetism as used here. As already stated, a large portion of the semicircular deviation at the standard positions of our ships has been found to be due to permanent magnetism in hard iron, a small portion of it and the quadrantal deviation being due to the soft iron of the ship taking up and parting with its magnetism very rapidly. Intermediate between this strictly hard and soft iron, and, fortunately, not evident in large quantities, there is found in every ship iron showing for a time the characteristics of hard iron, in causing polar deviations in the compass. It is, however, constantly liable to lose this polarity, either by lapse of time after the removal of the inducing cause, or its polarity may be reduced to zero, or totally reversed instantly by shocks inflicted on the general structure of the ship. The amount of deviation produced by iron of this nature has been found to vary for each ship, and to range from 1° to 6° or 7°; a great deal depending upon the proximity to the compass of the surrounding iron.

Now, no suitable corrector has as yet been found for deviations of this kind, and the only course open is that of constant observation and careful notation of the results for immediate and future use.

As vessels of war are specially under consideration, I would lay stress on the effects of firing heavy guns with the ship's head in one direction. Sometimes the violent shocks which the ship receives alter considerably the direction of the pull of the sub-permanent magnetism of the ship on the compass. The change gradually decreases in amount, occupying from a month or six weeks to a few days in returning to its normal condition. Considerable success in obviating these changes has been obtained by firing with the ship's head in various directions. For example, when simultaneous broadsides of five 13-ton guns were fired from the "Bellerophon" off Plymouth in 1886, with the ship's head in opposite directions, there was no change of deviation. Other instances might be quoted in support of this.

On conclusion 6, I would remark that up to the present time, the deviation caused by transient vertical induction in vertical soft iron continues to be of moderate amounts at standard positions in most of our ships—a very desirable result, considering that the use of correctors should be avoided when possible.

In dismissing that part of the subject relating to semicircular deviation, it may be said that, if sufficient care is exercised in preparing a place for the standard compass, experience shows that in modern war-ships the semicircular deviation is generally either of moderate amount, or of such a character that it can be corrected for all latitudes. Much may be done in a similar direction for the steering compasses, which are not very near thick vertical armour.

The vessels which have been thus treated of, have always been considered to be upright, or on "even beam," as it has been aptly termed, and there are still certain difficulties to be overcome before we can navigate them safely by the compass. I allude more particularly to the diminution of the mean directive force acting on the compasses at the protected positions on board our modern armour-plated and armour-decked ships, the large values of the quadrantal deviation, the great increase of their heeling errors, and the evil effects of swinging ships other than very slowly in one direction, either to starboard or to port.

Before, however, considering these difficulties, I think my reasons for thus accentuating them so strongly should be given, especially as at standard positions we are able to fairly sustain the conditions of twenty years ago; and no untoward result to navigation has happened during that time, depending in any way upon low directive force, or quadrantal deviation. I believe I am fully supported by many leading Officers of the day in the opinion, that compasses successfully placed in conning-towers and other protected places, so as to be nearly correct in showing the direction of the ship's head, and as a consequence the arc of the horizon through which the ship's head may be turned, are of the greatest importance. Compasses in our well-placed standard positions with closely corrected auxiliary compasses on chart-houses and bridges, from which all-round views

may be had, are all very well for taking the ship to the scene of action or for concerted manœuvres of the fleet without an enemy in sight; but I do not think I detract from British pluck when I say that in face of an enemy within range well provided with quick-firing and machine-guns, the Officer who went to observe at these exposed positions would, besides probably finding the compass *hors de combat,* seriously endanger a valuable life far more useful elsewhere.

On the Diminution of the Mean Directive Force to North acting on the Compass Needle.

It has been thought by many persons that as long as a position could be found in a ship where the deviations were moderate, or could be nearly corrected, such conditions were satisfactory for a compass used in navigating the ship. This idea is most illusory and even dangerous in its consequences, as it is easy to conceive a position where there may be no deviation, and yet the directive force is so low that the compass is not only very sluggish in action, but is liable to the effects of every temporary change in the magnetism in the surrounding iron, and all its mechanical defects are rendered doubly apparent. The following table gives the values of the mean horizontal directive force to north, or λ according to the notation of the Admiralty Manual, on board two of our modern belted cruizers, considering the earth's horizontal force $= 1{\cdot}0$. In six of our battle ships the λ at their standard positions varied from 0·800 to 0·855, which may be taken as common values for that class of ship.

Ship's name.	Standard.	Bridge.	Conning-tower.	Fore torpedo-flat.	Steam steering aft.
"Orlando"..........	0·762	0·616	0·212	0·660	0·720
"Undaunted".......	0·822	0 618	0·243	..	..

It will be seen by these figures that whilst as a rule 0·8 of the earth's directive force remains intact at the standard positions, only a little over 0·6 is found at the bridge compasses of the "Orlando" and "Undaunted." These latter compasses were placed on the fore bridge for convenience of steering as well as for taking bearings when the ship is going in and out of harbour, and other pilotage waters. They are secured in positions 6 feet above the conning-tower which acts as a gigantic Flinders' bar below it. Descending to the conning-tower, where the compasses are placed in the most advantageous position near the centre, the mean directive force is found to be only 0·212 and 0·243 respectively, or a diminution of rather more than three-fourths as compared with a position on shore. Thus a conning-tower with a plating of 12″ thick and two-thirds of that thickness

very soft iron as in the two ships mentioned, is about as bad a place as possible for a compass even when nearly corrected.

On the Quadrantal Deviation.

As long as the quadrantal deviation at any compass is not more than 8°, it may be considered as within manageable limits either for correction by soft iron or to be left for tabular correction. At standard positions in eight typical battle-ships, the quadrantal deviation varied between 5° and 8° 30′; but it is when the protected positions are examined, that the difficulties arise, for then we have generally a combination of limited space and large values of this deviation.

Table of Quadrantal Deviation, or Coefficient D.

Ship's name.	Bridge.	Conning-tower.	Fore torpedo-flat.	After steam steering.
"Orlando"	+4° 54′	+16° 9′	+18° 56′	+25° 38′
"Undaunted"	+4 7	+16 0	..	..
"Collingwood"	..	..	..	+20 30
"Dreadnought"	..	..	..	+21 0

The figures in the table show what is commonly found in protected positions, and they convey the certain information that compasses with such errors, combined with low directive force, are of little use unless closely corrected. How this is to be done will be fully considered towards the close. The attempt was made to correct the 10-inch Thomson compass at the armour-cross of the "Agamemnon," only 12-inch spheres being used on account of the cramped space available, but large and most inconvenient quadrantal deviations of 16° remained uncorrected, and the result was an undesirable compass for manœuvring purposes. Great efforts were made to correct a Thomson compass outside the conning-tower of the "Polyphemus," but they were unsuccessful, and the remaining deviations are constantly changing from the compass being so close to the iron. The only means to obtain anything like successful working, is to place the compass near the centre of the tower, for experiment has shown how futile it is to place it near the sides. Two instances when the compass was placed very near the sides of the tower will suffice to illustrate this: (1.) The "Curlew," lying N. by W. On visiting the tower the movable top was lowered to its full extent, the compass, a 6-inch Thomson, pointed to S.E., the top raised 2 inches, it settled at N.E., raised to 4 inches it showed N. by W.; in fact it was hard to make the compass point in any northerly direction at all. The correcting spheres too, became so strongly magnetized by induction from the tower that they had to be re-

moved as mischievously increasing the errors. (2.) In another tower in the "Conqueror," merely raising the small shutters to look out, altered the Thomson compass inside three points. It is therefore incumbent upon Officers in these ships to see that the movable top of the towers should only be raised to one determined height, if the compass inside and that above it, are to be of use.

On the Heeling Error.

As long as iron and armour-plated vessels were liable to heel under sail, the uncorrected heeling error was often a source of trouble, if not of danger to the navigator; especially if the ship were first on one tack and then on the other. With the sail-less ships of to-day, these conditions no longer exist, but the uncorrected heeling error has still a disturbing effect on the compass when the ship rolls, sometimes producing considerable oscillation of the card, or if that be apparently steady, an uncertainty in its pointing. As regards standard compass positions, the heeling coefficients have much the same values as in ships of twenty years ago, seldom exceeding $1\frac{1}{2}°$, often much less, and quite within the limits of easy correction. As with the two other coefficients λ and D, with which the heeling error is closely connected, it is when we approach the conning-towers and other protected places, that abnormal results follow. I do not think I can place the subject more clearly before you, than by giving the details of experiments made last year, when the belted cruizer "Orlando" was actually inclined, and the results of a subsequent series of observations made during her voyage to King George's Sound. This vessel, lying with her head magnetic south in Keyham Basin, was inclined 5° to starboard, and 5° to port, the ship's head by all compasses being noted for each degree as the vessel heeled over. The usual observations of vertical force were also made when the ship was upright. The calculated results from the force observations, and those from actual heel are shown in the table. Their agreement is not as close in all cases as I had hoped, but I do not think the late Mr. Archibald Smith, who gave the formula, expected it to be put to so severe a test. It is nevertheless a boon to possess so ready a means of obtaining approximate values without inclining the ship—a formidable task for every ship of the Navy.

The Navigating Officer of the "Orlando" was furnished with the usual instruments for observing the horizontal and vertical forces, and he sent into office observations for Colombo and King George's Sound. These have now been discussed with the following resulting table of heeling coefficients, in which those from actually inclining the ship are noted in italics:—

	Standard.	Bridge.	Conning-tower.	Fore torpedo-flat.	After steam steering-wheel.
Devonport	+1° 42′	+3° 28′	−0° 32′	−1° 15′	−1° 11′
	+1 10	*+2 50*	*−0 36*	*−1 36*	*−0 40*
Colombo	−0 36	−0 5	−1 47	−0 44	−0 38
King George's Sound	−1 14	−3 14	−6 17	−1 30	−1 13

To take one example—the above figures show that at the bridge compass when the ship heeled over 10°, on a north or south point, the heeling error would be about three points to the high side in England, and about three points to low side in Australia—a change of six points if not kept frequently corrected by magnets at different positions during the voyage.

The next table shows the relative portions of soft and hard iron in the vertical force of the ship, which is the principal element in producing the heeling error, k representing soft iron, and R, hard iron; and the vertical force in England being taken as 1·0. R may be corrected for all latitudes by a permanent magnet placed vertically under the compass; k should, according to the law that "like cures like," be corrected by a vertical soft iron bar. It is, however, more convenient to use a permanent magnet vertically *below* the compass, and alter its distance therefrom as necessary.

	k.	R.
Standard	+0·136	+0·039
Bridge	+0·419	+0·019
Conning-tower	−0·557	−0·318
Fore torpedo-flat	−0·474	−0·414
Steam steering aft	−0·545	−0·387

Note.—The sign + denotes a downward force, the sign − an upward.

At the bridge compass raised 6 feet above the conning-tower the heeling coefficient is shown to be abnormally large and changeable in character from its being almost entirely due to vertical induction in soft iron, the value of k being +0·419, of R only +0·019, which, added to the constantly changing deviation from the horizontal forces, makes the position one to be carefully avoided, except for steering purposes. It is true that as long as the vessel remained in one magnetic latitude, a compass in such a position might be kept with errors of a moderate amount, but the "Orlando" is a vessel intended for possible rapid changes of magnetic latitude, and it would therefore prove a very uncertain compass to trust to. There was, however, a standard position in this ship as usual, where the compass appears to have remained constant in its deviation beyond expectation.

Inside the conning-tower no heeling error of large amount was observed until the vessel reached south dip, and at King George's Sound, it assumed the unprecedented value, as far as I am aware, of about five points for 10 degrees of heel.

At the other protected positions below, the heeling errors proved more constant than at the standard, and capable of easy correction by a magnet.

Taking a general view of the results in the table, it may be remarked, that thick armour plating appears to be the chief cause of difficulty when dealing with a compass, as magnetically speaking it is almost entirely composed of soft iron, seriously reducing the directive force on the needle whilst producing large deviations of a constantly changing character.

On Electric Lighting of Vessels.

When everything has been done by carefully placing the compass, removing all the iron possible from its vicinity, and applying the necessary correctors, there still remains another source of danger to its successful working to be guarded against, which has arisen from the introduction of the electric light on board ship. Fortunately, experiment has now shown that with a well-designed installation, all trouble may be avoided, but I think it would be a want in the present paper if the results of experiments, and the sources of danger which have been discovered, were left untold.

The two causes of disturbance are the dynamo and single wire leads. Thus, experiments on board the "Euphrates" showed that the polarity of an Edison machine affected a compass at a distance of over 40 feet, and instances of disturbance from the dynamo in other vessels have been observed. Of the effects of single wires, an experiment on board the "Royalist" may be cited. One wire was lead under the standard compass at a distance of 13 feet, the return wire was separated only 5 feet from it. With a current of about 100 ampères, a deflection of 8° was observed in the compass, which proved an excellent galvanometer, the deflection increasing and decreasing for every variation of the current without oscillation. In our present state of knowledge, the prudent course appears to be to avoid the use of dynamos of large external field, to keep these machines at least 35 feet from the compass, and to take care, as far as possible, that both poles of the machine be at equal distances from the compass. It has been thought that iron bulkheads and decks would so alter the direction of the external lines of magnetic force of the machine that they would act as screens. This suggestion has not been borne out by experience and suitable magnetic screens have yet to be devised.

As regards the wires, the use of single wires with hull as return is to be deprecated, and the lead and return wires should be kept close together and carefully insulated.

I have used the expression "our present state of knowledge" in order to avoid any appearance of wishing to give a law for a matter

connected with electricity, a branch of science which moves onward at so rapid a pace.

On the Effects of Swinging Iron Ships only in one Direction.

I am not aware of a better means of illustrating the effects of swinging iron ships otherwise than very slowly in one direction, than that of bringing before you some of the results of a series of observations made on board the "Inflexible" in 1882. The compasses used were the Admiralty standard in one position, and a Sir W. Thomson's compass in another; the observations being made by the azimuth instrument of each compass, so that no errors due to comparing one compass with the other could creep in. It was generally found, that when the ship was swung opposite ways, to starboard and to port, on the same day, there was often a difference of at least 2° in the deviation for each direction of the ship's head at both positions. As much as 4° between the swinging to starboard and to port was found at a compass, when the surrounding iron was near and unsymmetrically distributed. The series of deviation tables from the "Inflexible" are very instructive, and form a valuable record of scientific and practical interest. The ship appears to have been swung in the usual manner as regards time, but it is evident that a vessel with such thickly-armoured decks and sides, and iron so close to the various compasses, must either be swung very slowly and steadied on each point, so as to allow the iron not strictly "soft" to take up the proper amount of magnetism due to the direction of the ship's head, or she must be swung opposite ways, and a mean result taken for the correct deviation. It should be borne in mind that the case of the "Inflexible" is one amongst many others, and the lesson to be learnt is applicable to all iron vessels of the present day.

The Disturbance of the Compass on approach to certain Shores.

The mariner's compass has yet another enemy to contend with in the magnetic disturbance caused by proximity to land. This reported disturbing effect is not now brought forward as a novelty, in fact it is an old story often told and discredited by many whose opinions were well worthy of consideration. Well authenticated reports of recent years show that both those who doubted and those who reported were both partly right and partly wrong. The facts are these: it is seldom, if ever, that the visible land disturbs the compasses of a ship, as her distance from the shore would almost in every case entirely keep her out of its magnetic influence. It is the submerged land near the ship's bottom which, possessed of magnetic properties, sometimes of attraction, sometimes of repulsion, produces the observed effects on the north point of the compass.

Now, I have brought this part of the subject forward, in order to place a clearly proved fact on a proper basis, and not with the view of alarming the seaman. We have now a list of localities, situated in different parts of the world, where the disturbance of the compass has

been noted by trustworthy observers, and I would raise a note of warning to navigators, prone to shave corners on a dark night, guiding their ships solely by the compass, that the rocks they approach with ample water over for the ship to float and be safe, may be so strongly magnetic as to deflect the compass, carrying the ship into serious danger if not destruction.

Observations tend to show that magnetic rocks in the northern hemisphere attract the north end of the needle, and therefore a ship nearing the land in moderate depths of water, say under twenty fathoms, on northerly courses, would be drawn nearer and nearer to them. In the southern hemisphere the converse appears to hold good, the north end of the needle being generally repelled, and a ship steering on southerly courses might be liable to close the land without her Officers knowing anything about it. There is no need here to enlarge upon the results of an iron ship's merely touching the ground, much less striking on a rocky bottom. Two well-established examples of disturbing localities will help to illustrate the foregoing remarks, which are the outcome of considerable inquiry.

The first is the case of our surveying vessel "Meda" at Cossack in North Australia. Here, with the visible land three miles off, the "Meda," running on a transit of two objects on shore, in 8 fathoms of water, had her compass steadily deflected 30° for a quarter of an hour during which she sailed over a mile.

The next instance is that furnished by observations of the variation of the compass on the East Coast of Madagascar. The normal lines of the variation for several miles of the coast from St. Mary's Isle southward should vary from about 11° W. to 12° W., but instead of this the French men-of-war, which are frequently running up and down this part of the coast, find that the variation near the shore at St. Mary's Isle is only 6° or 7° W. and 12° W. at 80′ south, the north end of the compass being repelled by the magnetic properties of the bottom. These results are analogous with those of observations on shore in Madagascar, New Zealand, and other places.

On the Magnetic Character of Torpedo-boats.

As torpedo-boats are an entirely novel form of fighting vessel, introduced since the paper of 1872, a few remarks on their magnetic character may be acceptable.

It may be said at once, that with the standard positions there is every reason to be as fully satisfied as with those of any other iron vessel. The semicircular deviation seldom exceeds 12° or 14°, the quadrantal is generally +4°, and the mean directive force is satisfactory. The compass, therefore, is easily corrected by magnets and soft iron; the small remaining deviations of about 2° being fairly permanent in spite of the constant vibrations to which the boats' hulls are subjected. The steering compasses have generally to be placed near the sides of the turrets with semicircular deviations of some 30° or 40°, the maximum of quadrantal deviation being sometimes 8° or 10°, at others 3° or 4°; but this is a subject which is

receiving attention, with a view to placing the compasses in more satisfactory positions.

Modern Systems of Correcting the Deviations of the Compass.

Very little has been said as yet on the question of correcting the errors of the compass, but the readers of the Journal of this Institution will remember how fully Sir William Thomson described the manner in which he had applied Sir G. Airy's system of correctors to his patent compass, as well as the Flinders' bar.[1] Subsequently to this, in the Journal for 1882, there is a paper by myself, "On Compass Correction in Iron Ships." I, therefore, propose to confine my remarks to the latest phase of the question.

It is commonly remarked, that either a compass is sluggish and will not move, or that it is excellent and moves directly the ship's head moves. Now the ideal compass on board ship is one in which the card refuses to move at all, and steadily and strongly points to magnetic north while the ship and compass bowl turn round it as required by those in command. It should have no work to do in the shape of turning to starboard or port, to bow or stern, in obedience to the magnetic forces existing in the ship, and the directive force of the earth should be interfered with as little as possible. How far the compasses on board our iron and armour-plated vessels fall short of this ideal is shown by their deviations, which, at best, are but reduced to a small amount for a given time and place, whilst constancy of deviation may be said, as yet, to be unattainable.

The reason is obvious: the correctors we use are constant in their action, whilst a portion of the magnetic forces they are intended to oppose is for the most part variable in amount and direction. With well-placed compasses there should be no difficulty in reducing the deviations to a minimum amount of 2° or 3°, subject to changes from firing heavy guns and running for some time on one course; it is when we come to conning-towers and other protected places that trouble arises, first in making the correction and afterwards maintaining it. Our difficulties lie in the correction of large quadrantal deviations ranging from 12° to 30°, and increasing the low directive force. The polar deviations must be left to the care of the magnets, but let us inquire what can be done for the quadrantal.

Beginning with the best form of Sir W. Thomson's compass—the 10″—and supposing that the "Orlando," as a typical ship which we know so well, is provided with them on the bridge, in the conning-tower, and the two protected stations below, what happens? At the same time bear in mind that Sir W. Thomson lays special stress on the close correction of his compasses, for he naturally wishes them to be like the ideal compass just mentioned and inexorably point to the north.

At the bridge compass the quadrantal deviation is only about 5°, and can be readily corrected by a pair of 7″ spheres, which also help to correct about 44′ of heeling error for every degree of heel on

[1] See papers of February, 1878, and May, 1880.

the north and south points till the first 5° of heel are reached, but gradually decreasing in their power as correctors as the ship inclines further. Inside the conning-tower, the quadrantal deviation is a little over 16°, requiring a pair of 18″ spheres to correct it. These spheres add about $1\frac{3}{4}$° of heeling error for every degree of heel.

On the fore torpedo-flats the quadrantal deviation is 19°, requiring correcting spheres of 20″ diameter, and adding largely to the heeling error which might otherwise be kept nearly correct in all latitudes by a permanent magnet.

At the after steam steering wheel the 26° of quadrantal deviation must have at least 24″ spheres, again adding largely to the otherwise moderate heeling error.

Again, the effect of spheres is to reduce the directive force on north and south courses, and to increase it on east and west, their general effect being to slightly increase the mean directive force to north on the compass, to correct the quadrantal deviation, and to introduce heeling errors sometimes of a beneficial order, but in some cases producing adverse complications.

In positions below such as we have considered, and specially in conning-towers, the great size of the spheres required for accurate correction makes their use almost prohibitive, and in many ships there is no room even for the moderate sizes. Moreover, we have seen that the directive force is so low that one instinctively inquires why cannot these large deviations be corrected by some system which requires small space, say, within a circle of 20 inches, and at the same time sensibly increases the directive force which is so sorely needed?

By reducing the size of the compass somewhat, I have reason to believe these objects may be attained, and the compass card may be given needles of great directive force, which, instead of being a hindrance to correction, are a benefit.

In order to possess clear views of the quadrantal corrector I am about to describe, a short explanation of the principles upon which it is based seems necessary.

The well-known example of soft iron rods, placed in a horizontal plane passing through the needles of a compass, will help towards this

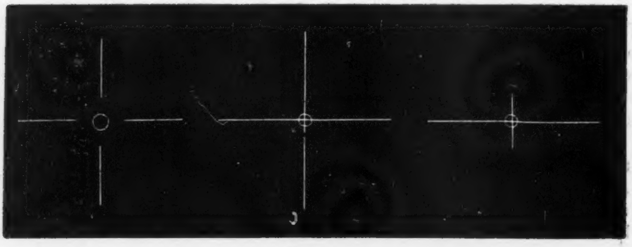
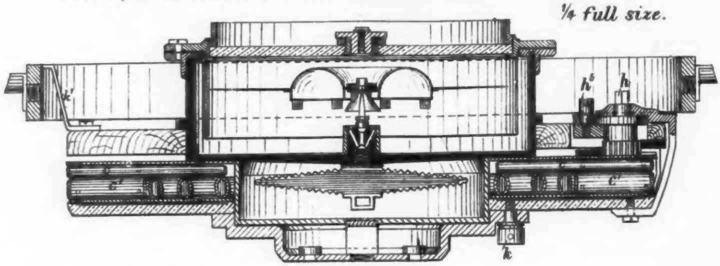


FIG. 1. FIG. 2. FIG. 3.

SECTION OF COMPASS FITTED WITH THE PEICHL QUADRANTAL CORRECTOR

¼ full size.



h^5 CLAMPING SCREW.

h SCREW FOR D MACHINERY.

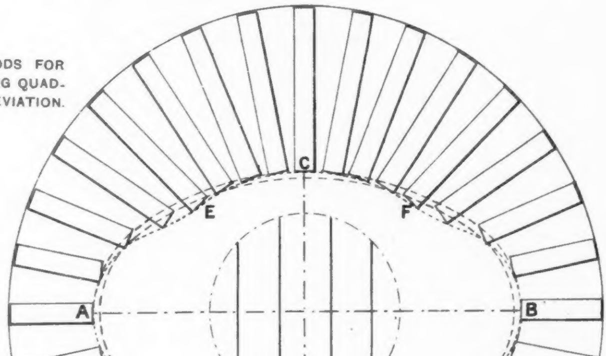
k CLAMPING SCREW FOR SETTING THE QUADRANTAL CORRECTOR FOR OBLIQUE DEVIATIONS $\pm$ E.

k^1 INDEX FOR THE CORRECTION OF $\pm$ E.

c SOFT IRON CORRECTING ROD OF UPPER SET OF RODS.

c^1 SOFT IRON CORRECTING ROD OF LOWER SET OF RODS.

PLAN OF RODS FOR CORRECTING QUADRANTAL DEVIATION.



THE CURVE A E C F B H D G, WHICH SHOWS OCTANTAL DEVIATIONS FROM AN ELLIPTICAL CURVE SERVES TO CORRECT BESIDES THE QUADRANTAL DEVIATION ALSO THE OCTANTAL ERROR.

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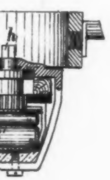
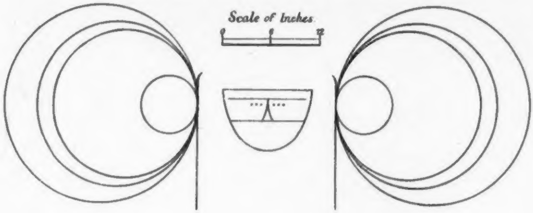


SPHERICAL QUADRANTAL CORRECTORS FIXED TO BINNACLE TO CORRECT VALUES OF D IN ORLANDO.



ONS ± E.

Figs. 4, 5, 6, 7, 8, 9 *are not drawn to scale.*

Fig. 4.

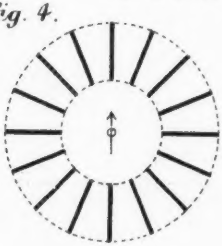


Fig. 5.

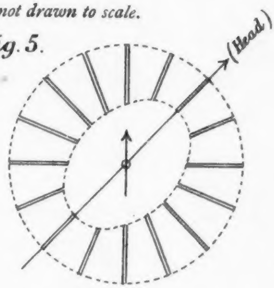


Fig. 6.

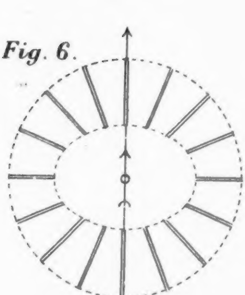


Fig. 7.

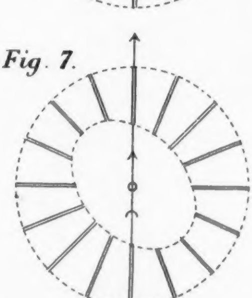


Fig. 8.

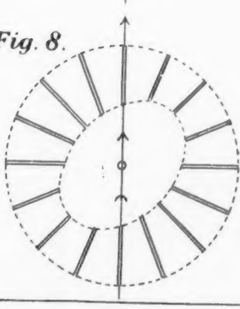
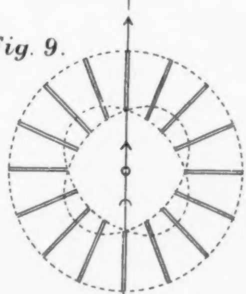


Fig. 9.



ONS. LITH, ST MARTINS LANE W.C.

purpose. Thus, in Fig. 1, the equal rods *increase* the directive force but produce no deviation. In Fig. 2 the equal rods *decrease* the directive force but produce no deviation. In Fig. 3 the transverse rod is much longer than the longitudinal, and the deviation of the compass is caused as well as loss of directive force. It is soft iron, represented by rods of the type Fig. 3, which produces the low directive force combined with large quadrantal deviation on board ship. Therefore, reasoning from the effects of the rods in Figs. 1 and 3, we have only to place round the compass soft iron rods of the type Fig. 1, but of different lengths, so as to counteract the forces of the unequal and detrimental iron of the type Fig. 3. This solution of the difficulty of correction has been most cleverly worked out by the Chevalier Peichl of the Austro-Hungarian Navy, and a compass with corrector, invented and patented by that Officer (see Plate), lies before you on the table; but as the system of soft iron rods is concealed by the woodwork, reference must be had to the diagrams for explanation. I may remark here that this corrector has been adopted for five years in the Austro-Hungarian Navy with great success.

Using the notation of the Admiralty Manual which is now common to the world, the parts of the quadrantal deviation are known as coefficients D and E. The following is a translation of the inventor's description of the instrument:—

"The quadrantal corrector forms the principal part of the instrument in question. The action of this corrector is easily derived from the following considerations: an arrangement of perfectly soft iron rods, and of equal dimensions, disposed radially round a compass at equal distances from the card (Fig. 4), can produce no other effect than that of increasing the directive force, for then it is only a multiplier of intensity. But if, on the contrary, these rods were no longer equal in such a manner that their interior ends form an ellipse (Fig. 5), of which the major axis is parallel to the keel, that different arrangement will produce a multiplier of intensity which at the same time will be capable of compensating a given value of the positive quadrantal deviation, since it produces a negative D. In the positions of this arrangement shown by Figs. 6, 7, and 8, the effects are $+D$, $+E$, $-E$; and in the intermediate positions, the relative portions of D and E will result. Now the quadrantal corrector consists of two sets or systems of soft iron rods placed one above the other, and movable in opposite directions round the compass bowl. Fig. 9 represents their position when the index is at zero. One sees by that that they produce $+E$ and $-E$, and that consequently their total effect in that position is *nil*. By turning them in the direction indicated by the arrows, the position will be reached when the major axes of the two ellipses are parallel to the keel. This is the position of their maximum effect, and it is marked on the index as 1·0. The value of this maximum effect depends upon the details in the construction of the instrument, that is to say, on the length of the bars, and the distance of their interior ends from the card respectively with the form of the ellipse."

The action of this corrector is due especially to the induction of

the compass needles in the soft iron rods. This necessitates an adjustment of the corrector on change of latitude, for which an index and scale are provided for all latitudes, and is of a very simple nature.

"This quadrantal corrector produces an increase of directive force for every direction of the ship's head."

I have experimented with this instrument in the conning-tower of the "Medusa," and I found I could correct 30° of quadrantal deviation for all latitudes, and for the coasts of the United Kingdom about 44°. These advantages, coupled with the increase of directive force on all azimuths, and the small space occupied, have led me to hope that this instrument will meet a deficiency in our present compass equipment. Before concluding the description of this corrector, I may point out another valuable property connected with it. As the ship proceeds to parts of the world such as Quebec and the St. Lawrence, where the horizontal force of the earth is smaller than in England, so the directive force of the instrument increases, making the compass point with greater energy than with any other system.

In a paper read last month at the Institute of Naval Architects, Mr. W. W. Rundell, who may be styled one of the fathers in compass matters, discussed the question of correcting certain compass errors caused by iron unsymmetrically placed near a compass. His arguments tend to show that these errors are such as would be produced by one horizontal and one vertical bar of soft iron unsymmetrically placed, and that the corrector should be an inclined bar of soft iron, the position of which is to be found from an analysis of the observed deviations. I am testing his propositions experimentally, but am not yet in a position to give an opinion upon them.

General Observations.

Every now and then it is reported that the mariner's compass which has served the navigator on the ocean and the traveller in the trackless forest so faithfully for hundreds of years is about to be superseded by an instrument which shall always show the true north. The idea is captivating, and its realization would be a boon when we call to mind what has been said of the compass in ships of war. Such an instrument therefore must be independent of all magnetic influences. It is true that in 1852 Léon Foucault showed that the gyroscope takes up a direction parallel to the earth's axis. Foucault writes: "Then without the help of any astronomical observations the rotation of a body at the surface of the earth suffices to indicate the plane of the meridian." Sir W. Thomson, at a meeting of the British Association in 1883, also described a form of gyroscope, which, when rapidly rotated, showed distinctly the direction of the true meridian.

The question as to the motor of such an instrument, which should at once be automatic and continuous, has not yet been answered, and I think we shall for the present do wisely in treating the compass fairly, knowing full well that the earth's magnetic force is ever present to direct it.

The words "Mariner's Compass" cover a great variety of means for utilizing the one great principle of the earth's directive force, in the shape of a large number of compasses patented and otherwise. Finality has not been reached by any one of them, nor is it likely to be. Still we must always feel grateful to inventors for the many valuable aids they have provided for safe navigation; but those who have to report on inventions, and have the good of the Service at heart combined with due economy, must always be on their guard, remembering that they have to deal with individuals often pleasant, persuasive, persistent, and perceptive of everything but possible faults in their inventions. Amongst the many patents, I will only mention Sir W. Thomson's compass, the valuable qualities of which under certain conditions are so well known and require no special notice here.

There is another compass to which I would draw attention, and that is the liquid compass, which, if properly constructed, is one of the most generally useful instruments of navigation yet made. In torpedo-boats, and some of the latest types of fast cruizer steaming under forced draught, the liquid compass has acted well when every other compass failed to a serious extent or was practically unserviceable. It has been in general use in the United States Navy for many years, and in their official book of "Notes on Chronometers, Compasses," &c., the following occurs: "It may then fairly be concluded that the United States Navy is possessed of a compass unsurpassed in its essential qualities by those in other services whether naval or mercantile."

It is used universally in the Austrian and German Navies, and also as a standard compass in the Italian Navy, I, therefore, say without hesitation, apart from such witnesses to its value, that we must hold fast to such a friend in need as it has lately proved, doing all that is possible to perfect it as a part of the necessary equipment.

As to the placing and correction of compasses in our vessels of whatever type, the departments at the Admiralty are working heartily together. The Controller of the Navy, at the request of the Hydrographer, has lately issued revised instructions to meet the requirements of the day, with a view to providing as suitable places for all compasses as the fighting necessities of a war-ship will permit. With the sources of error thus eliminated as far as may be, the work of providing suitable compasses and correctors is a constant subject of earnest enquiry in the department to which I have the honour to belong, and the strength or weakness of the several compass positions is fully proved.

It is not necessary to ascertain the magnetic character of every ship as has been done in the "Orlando" and "Undaunted," as a number of ships of one class or type are generally built, and the full knowledge of one or at most two of each type furnishes all the most useful and necessary data for the rest.

The care thus bestowed is none too much, although it is sometimes asserted that correctors can do anything—and, lest a good way should come to be evil spoken of, I will quote a few lines from a work pub-

lished by the United States Bureau of Navigation after they had made a searching inquiry into the subject of compass errors, and their treatment in iron and steel ships:—

"From all that precedes, it will readily be inferred that to place a compass where the magnetism of the ship will least affect it, is essential both to the safety of the vessel, and to the good behaviour of the instrument itself." Again, "Compensation of large deviations by means of magnets is at best but a remedy for an ailment; better not sow the seeds of the disease."

I should add that this inquiry was accompanied by experimental tests of the truth of Archibald Smith's mathematical theory of the deviations of the compass.

There is yet another point upon which I would make a few short remarks, that is on the constant changing of the correcting magnets of the standard or navigating compass, by which the ship's course should be shaped, even if not so conveniently at hand as the badly placed auxiliary compass. The word "standard," as here used, refers to a position, not to any particular form of compass.

If the changes of the semicircular deviation range from zero to 4° or 5°, I think it much more advantageous to leave them alone, and trust to frequent observation for ascertaining the deviation, entering each observation in a compass journal for future reference. Should the semicircular deviation change largely and permanently, it would, no doubt, be right to correct it, taking care to swing the ship immediately after to ascertain remaining deviations.

These recommendations do not refer to manœuvring compasses, which it is most convenient to keep as nearly as possible correct, Commanding Officers giving opportunities for making the corrections as required.

As to the compass journal, it is largely used in the navigation of the many noble vessels of the mercantile navy, and a constant changing of magnets is generally deprecated by their eminently practical commanders.

Touching the question of education in matters relating to the compass, every means has been adopted for imparting sound information to Officers. At the Royal Naval College, Greenwich, the seniors find able instruction of a most practical kind. At the College in Portsmouth Dockyard, every Sub-Lieutenant goes through a most useful course, illustrated by models and practical adjustments in an iron gunboat at Spithead. They are also supplied with a pamphlet of instructions in compasses and their treatment in iron ships, issued by order of the Admiralty.

After all that has been said, true science teaches us a never-to-be-forgotten lesson. Observe the deviation when possible, note it in a book, and learn its changes under every circumstance as you do the rate of a chronometer. Then on some thick dirty night, the reward will come in the shape of a reasonable confidence that you can steer the required course without delay and detriment to the service upon which the ship may be ordered.

The CHAIRMAN: I may take this opportunity of saying that I have received a note from Sir William Thomson, addressed to the Chairman, regretting not being able to be present to-day. I am sure you will all join in that regret.

Admiral Sir ERASMUS OMMANNEY, F.R.S.: I am very glad to find that we have this subject brought before us again after such a long interval, for it is now seventeen years since Sir Frederick Evans delivered a most instructive address here regarding the magnetization of iron ships and its effect on the steering compasses. During this interval a wonderful alteration has been progressing in the construction and in the metal of iron ships, likewise in the improvement of steering compasses; we are therefore grateful to Captain Creak (the able successor to Sir F. Evans) for the instructive paper we have now heard, containing so much scientific and practical information of great value. I will not attempt to criticize this paper, coming from such an eminent expert as Captain Creak, than whom there is no higher authority in the kingdom on this important question. In my opinion the author of this paper has put the whole matter before us, as it now stands, most completely. I regret to observe so few naval Officers present. Let us hope this paper will be read elsewhere, very extensively, beyond this room. The influence and effect of magnetism, which operates so mysteriously and invisibly over the surface of the earth, renders it more incumbent for the mariner of the present day to study more attentively this branch of science and the properties of this secret agent which possesses an individuality in every metallic ship which traverses the wide oceans, in order to secure accuracy for its navigation. I am sure we are all much indebted to Captain Creak for producing this very instructive paper.

Captain WHARTON (Hydrographer to the Navy): Captain Creak's very able and lucid paper so fully covers the ground and opens up so many questions that there is not much left for me to say. I may remark in starting that I heartily agree with all that he has said, although I do not pretend to be such an authority on the subject as he is. I think he very prominently brought to everybody's mind the enormous difficulties that there now are in correcting compasses on board our men-of-war. For some years there have been difficulties, but it is not too much to say that they increase every day. There is no doubt that in war-time the compass you will want is a compass that you can depend upon in a conning-tower, and these are just the compasses I am sorry to say that at the present moment are not at all reliable. The admirable invention of Sir William Thomson fails there, because in these protected positions, as Captain Creak showed, you have not room to place a compass with large spheres. Those enormous spheres not only take the whole space in these limited towers, but to a certain extent they introduce error. Captain Creak referred to the invention of Chevalier Peichl, whose compass has been introduced into the Austro-Hungarian Navy for the last five years. I believe it has been under the consideration of the Admiralty nearly as long as that, but recent improvements of Mr. Peichl's have led Captain Creak to make further experiments, the results of which are so encouraging that we are getting some more of them over to try in our ships and test their efficacy thoroughly. If it answers as we hope, it will go very far towards solving that most important question of getting the compass to work in these extremely awkward positions with large masses of iron near it, and at the same time it will take up less space. I only hope our anticipations may be justified. I may mention in connection with the difficulty of fixing the position of a ship that I have been for some time most anxious whenever there is an opportunity to inculcate the use of the station pointer. I am happy to say these instruments are now being issued to all ships, and I hope with a little practice we shall come to recognize the extreme value of that system, which in time of war, in action, and also in time of peace, in ships where there are so many obstructions to clear view from the compass, enables you to fix the position extremely accurately from either a protected position or a position where, by inclining your head a little, you can see the object which in a modern ship of war you cannot possibly get from many of the compasses. Captain Creak has brought forward the question of the disturbance of the compass on approaching shore. For a long time it was thought not possible that the compass could really be disturbed. By well-known magnetic laws the sphere of influence of any disturbing forces is so small that it was felt quite impossible that the compass passing a point of land should ever be disturbed by the

magnetic character of the rock. But in some extraordinary manner it has been overlooked that while a ship is a long distance horizontally from land, she may be passing very closely vertically over it in shallow water, and it has only been recently recognized that this is the true explanation, and that there really is a danger in certain places, the majority of which are quite unknown, in passing over shallow water, of the compass being seriously deflected. I believe now that it is known it will be borne in mind. I can only conclude by saying that I hope that our motto will always be "Onward." Finality is by no means reached. We have a very difficult task in deciding what is the best form of invention to take up. It is very slow work indeed experimenting, but I feel very safe with Captain Creak at the head of the Department looking after it. I know that he has not only a very open mind, but he has the fullest knowledge of the subject, and I have every hope in time that we shall arrive at a more satisfactory condition of the compass in awkward positions than I am afraid exists at the present moment.

Captain Mayes: I wish to bear testimony to the great value of the paper read by Captain Creak. It shows the difficulty there always has been to correct the deviation of the compass in positions where the space is limited in iron ships. It is too technical a subject to go into very much, but I will just mention a few things that I have noticed. Captain Creak spoke of permanent and sub-permanent magnetism. In the very earliest days, Sir George Airy, Astronomer Royal, spoke of a part of the magnetism of an iron ship as "permanent." He afterwards thought proper to change the term to "sub-permanent." From that time to this there has always been a doubt in the minds of many people as to which is "sub-permanent" and which is "permanent" magnetism. I cannot help thinking if we use the word permanent only, instead of permanent and sub-permanent, we should be able to express all that is required, recollecting that the magnetism of a ship is, like most sublunary things, permanent only for a time. The correction of the heeling error is unsatisfactory, and the formula given by Mr. Archibald Smith does not appear to be correct. I have always found a difficulty in dealing with it, and I do not think that difficulty is quite got over yet. With regard to the electric light, when first it was introduced into the Service, electricians were very confident that the iron about the dynamo would conduct away and shield the compass from all disturbing influences. But they seemed to forget that we are dealing with magnetic force and not electric force. Magnetic force may be transposed but cannot be cut off by iron. The only way I can see out of the difficulty is to intervene between the compasses and the dynamo a bar of iron so magnetized by a wire carrying a current when the dynamo is running, as to set up a counteracting magnetic field. There is no way of insulating it that I can see. The effect of swinging the ship to port and starboard was known many years ago. It was first spoken of by the Liverpool Compass Committee. The "Defence" was swung in 1865 both ways, showing a maximum difference of 3°, the maximum being on the north and south points. I have never seen an explanation of this disturbance of the needle which has quite satisfied me. With regard to the disturbing effect of land upon compasses, that has been known since the early part of the century; but as the Hydrographer says, it was generally forgotten that land was very near the ship sometimes when it was spoken of as being miles away. When men spoke of land, they thought of dry land, not of the wet land under the ship's bottom. With regard to torpedo-boats, some have been swung after various intervals of time, and I have been much struck with the very great permanence of the deviation of their standard compasses. The compass in the conning-tower presents insuperable difficulties for want of space wherein to apply the necessary correctors, even to the smallest compass. Captain Creak has alluded to a recent paper by Mr. Rundell. I may state with reference thereto, that no iron bar can be placed about a compass in such a manner that its deviation cannot be expressed by Archibald Smith's formula. The last part of Captain Creak's paper is perhaps the most important, that relating to the education of naval Officers on the subject. I am very pleased to hear that it is going on so well, but it has been going on several years now, and I think it is quite time that we got something out of it. This will never be the case until the Admiralty insist upon naval Officers putting to practical use the education which it has cost so much to impart. If it were once made clear that Officers are expected to adjust the

compasses of and swing their ships, even if the duty were not immediately made compulsory, it would be one step towards abolishing the present inefficient system. I do not know that I have anything else to say upon the paper, excepting that I think Captain Creak has done good service in reading it.

Admiral Colomb: There were one or two points that struck me in the reading of the paper. I rather thought the lecturer explained better than I could, and it seemed satisfactory to my mind, the difference in apparent deviation when the ship is swung the opposite way, that it was the time required for the magnetism of the ship to, as it were, re-assert itself. I have never understood it before, but it does seem to me to be a satisfactory explanation. I would ask him in his reply whether that is what has been called Gaussin's error. I would like also if he would answer another question. Some time ago there was a strong correspondence—I must say, that with my slight knowledge, to be a rather senseless correspondence—in the mercantile marine papers, and I think in the "Nautical Magazine" also, referring to deviation of the compass in fog. May it not be that in approaching the land in a fog the shallow water had affected the compass, and that the idea arose in that way? Unquestionably all that has been said, speaking practically, about the necessity for getting some reliable compass in those parts of the ship where alone in action the command is to be—conning-towers, or whatever they may be—is exceedingly important. One is delighted to think that we may be getting hold of something of that sort in this Austrian compass, but I have always felt myself, in all these cases of the protected command of the ship, that the point is to get everything out of that place, and to have nothing but the Officer commanding, with the staff which it is necessary for him to have, to have no instruments whatever of any kind inside those places. I do not know whether anything has been done in the direction of reflection, but I cannot help thinking that we might use the principle to some extent. You might move the compass to a suitable distance and merely have the face of it reflected by a series of looking-glasses into the place where you want to see it. To my mind the trouble is analogous to what we have had in conveying the words of command, and the telegraph signals working them from the conning-tower, and I have always aimed, as long as I had power in that way, at getting apparatus away from that place, allowing the Captain's voice simply, without tubes or anything of the sort, to communicate downwards to the spot where the telegraphs and tubes and everything else were, so that he should not be troubled about anything except giving his orders. In the same way if he had merely the reflection of the compass before him I think it would be all he would probably require. My own predilections, as far as they go, have been, I must say, in favour of shifting magnets rather than fixed ones for correcting deviation. I have always thought very highly of Sir William Thomson's plan, but I am not sure I ever went so far as to think you should dispense with the standard compass and recording the magnetic changes in the condition of the ship, but I certainly have found much benefit in having a compass where you could continually correct it on the spur of the moment. For instance, when I was in the Steam Reserve at Portsmouth I had to take ships to sea, knowing nothing of their deviation, and to be at sea for eight or ten hours, liable, as happened to me once or twice, to get into fog, not knowing where you were or what you could do, with a compass that you could not trust. The plan I adopted was this. My Staff Commander laid down a series of transits as we were going out—altering the ship's head, taking the transits and correcting a Thomson's compass by them, after which we could fairly trust it. At any rate we were in a better condition from having a compass that we could correct, however roughly, than in being caught in a fog at sea without a compass that you could trust at all. I have been extremely pleased with the lecture, and I only wish that I had been more competent to follow it accurately.

Captain A. C. Parr: As the instruction of Officers at the Naval College at Greenwich has been referred to, I, as one who has been going through a course there, should like to bear testimony to the extreme interest which I have felt in doing so. Before I went there I understood nothing about the compass, and my instruction with regard to any corrections has been absolutely *nil*. As to being able to understand or get any benefit from the Admiralty Manual, I am afraid I did not succeed like **Admiral Colomb** in tracking the murderer to earth at all. I simply

could not understand it. But now I must say, having gone through a course of instruction at the Naval College, I have been able to follow this lecture with very great pleasure, and to thank the lecturer for it, and to feel the benefit which I have received from that course. I am also very glad indeed that the Sub-Lieutenants are receiving instruction in the compass, for I think there is the proper end to begin at. If the midshipmen know something about it, as they go on they will be able to develop and to obtain very useful information. How long the course of instruction at the College has been going on I do not know, but certainly we have many capable Officers already instructed, who would be perfectly competent to carry out any observations that might be required, and I have no doubt that we shall very soon see the results which one gentleman who has spoken hopes may soon be visible. I will conclude by thanking the lecturer for his paper.

Captain CURTIS: I might suggest to these young gentlemen, the midshipmen, that they should get a small magnet and experiment with it. One of the prettiest effects of magnetism is to take the kitchen poker, and just hold it in a line north and south, at an angle of 67°, give it a blow or two with a mallet or hammer; one end of it will become the north pole and the other the south, and you then reverse the poker and give it another blow, and you reverse the poles. I am sure that such an experiment would set any midshipman or schoolboy wondering at the effects of magnetism and excite his curiosity for more knowledge. I might also suggest, permanent magnetism is due to the hammering of iron in the manufacture of a ship, and also when she is twisting and turning about;[1] the firing off the guns, we suggest is that sub-permanent magnetism is produced. A ship is always altering the magnetism; when she is in the north and south line she increases it by induced magnetism of the earth, when she reverses her head she reverses the current, consequently the compasses are always liable to be corrected, "in fact magnetism is not a constant."

Sir ERASMUS OMMANNEY: Might I ask whether any amount of deviation has been detected in the magnetic character of a ship during its lifetime?

Admiral LINDESAY BRINE: As I did not hear the whole of the lecture, what I am going to say may have already been touched upon. The first point I notice is where the lecturer spoke of heeling error. I do not know whether Captain Creak means this, but he says that when a ship heels over the error is as much as 10°.

Captain CREAK: It is sometimes as much as 30°.

Admiral BRINE: I observe that in the paper you say it goes up sometimes three points on one side and three points on another. Now as regards this other very important point about the disturbance of the compass on approaching the land. You say in the case of one of your surveying vessels that running on a certain course you found the compass was "steadily deflected 30° for a quarter of an hour, during which she sailed over a mile." I suppose that would depend very much upon the nature of the ground over which she was going. Is it known what was the nature of the bottom at the point where that ship sailed over? Was it volcanic or some rock of a known character other than volcanic? I would also ask the value of the vertical attraction as compared with horizontal attraction when a ship is going over land nearer the bottom. I have never understood that to any extent the vertical attraction affects the compass in a horizontal direction. I suppose that this subject has been worked out. If you would be kind enough to answer the question it might be useful.

Captain BEALL (Board of Trade): As my experience is connected entirely with the mercantile marine, I fear I shall not be able to add much to the value of the discussion, but there are two or three points in the paper I should like to remark upon. Captain Mayes spoke just now about the term "sub-permanent magnetism." That is a point I really do not quite understand in the paper. The officers of the

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[1] "Some Curiosities of Magnetism," lecture at the London Institution, February 11, 1889, by Shelford Bidwell, F.R.S. A rod of iron which has been magnetized by the action of the magnetic field is found generally to retain some of its magnetism when withdrawn from the field. This "*residual magnetism*," as it is called, is held much more tenacious1y by hard steel or iron than by metals which have been softened by careful annealing.

mercantile marine, and, indeed, nearly all writers on the subject, regard sub-permanent magnetism as referring to the permanent magnetism of an iron ship as distinguished from the permanent magnetism of a permanent magnet, or magnetized steel bar, and consequently they would correct that magnetism with a permanent magnet. Captain Creak appears to apply the term "sub-permanent magnetism" to something between permanent magnetism and transient induced magnetism, or what is commonly known by the term "retentive" or "retained" magnetism. I might explain myself more clearly, perhaps, by referring to two or three extracts I have here. This is from "Towson's Practical Information on the Deviation of the Compass, for the use of Masters and Mates," a work that was really prepared as a text-book for the Board of Trade examinations. He remarks: "From what has been said it will be apparent that the term 'permanent' is not accurate when applied to the magnetism of an iron ship. Dr. Scoresby perceived this, and proposed to designate as 'retentive magnetism' the portion of the magnetism acquired on the building slip, which was retained after launching, and which he considered was retained only for a period, and under certain circumstances might be lost altogether, or even reversed. But experience has shown that this is a misapprehension, for although a ship does not retain the whole of the magnetism acquired on the building slip, yet it is certain that in all our iron ships some portion of the magnetism so acquired remains permanent. And we agree with the Astronomer Royal, Sir George B. Airy, in calling this residual magnetism 'sub-permanent magnetism.'" On the other hand, to put it briefly and clearly, the term is now applied in the following sense in the Navy. This is taken from "The Course of Instruction for Acting Sub-Lieutenants," published by the Admiralty: "Perfectly soft iron as here defined is rare, and the soft iron in ships requires a certain time to fully acquire and lose the induced magnetism. When this time is very perceptible—amounting often to many days—the magnetism induced is called sub-permanent." It is evident, therefore, that in the Royal Navy "sub-permanent" refers to induced magnetism, and in the mercantile marine, and indeed by nearly all writers on the subject, to the permanent magnetism of the ship. I think it is rather unfortunate that the term "sub-permanent," which is so well known, should now be applied to two different, in fact, opposite, things. I may say it was rather confusing to me, although I am not new at the subject. Therefore, I am sure it must be so to a great many of those who have but little knowledge of the subject. There is one more point I should like to remark upon, and that is in regard to the following sentence:—Captain Creak says: "At the bridge compass the quadrantal deviation is only about 5°, and can be readily corrected by a pair of 7″ spheres, which also help to correct about 44′ of heeling error for every degree of heel on the north and south points till the first 5° of heel are reached, but gradually decreasing in their power as correctors as the ship inclines further." Now, I do not quite see this, but probably I may not understand the remarks in the sense intended. It appears to me that their power as correctors, instead of decreasing after the ship heels 5°, is really increased till she has heeled over, say, 25° or 30°. Put it this way. Suppose you compensate a quadrantal +D of 5° by spheres, in the ordinary way. You then put the ship's head north and heel her over; you would then find when she has heeled over 5° that these spheres would compensate about 2° of heeling error; at 10° heel, about 4° of heeling error; at 15° heel, about 6°; at 20° heel, about 8°; and when at 25° heel, about 10°. It appears, therefore, to me that it is a continually increasing power as the vessel goes over instead of decreasing. I do not know that I have anything further to add, but I should like to be allowed to express my thanks to Captain Creak for his very able and interesting paper.

Colonel BAYLIS: Would you forgive me for rising to ask a question? I feel that this lecture is more than usually important, it is one of universal interest. I have derived a great deal of information from this admirable lecture. There is one point which struck me before coming into this room. It is only perhaps a rudimentary question, and therefore will be most easily answered by the lecturer, and as the Journal goes far and wide throughout the world I think probably what has struck me has struck others also, and they would like to have the answer. I know something of the variation of the compass and the adjustment of the compass, and so on, and it often occurred to me whether it would be possible to get some material which

will so isolate the ship's compass that it will not be subject to other magnetic properties or influences of external matter. The lecturer has stated that the introduction of the electric light on board ship has been a source of danger to the successful working of the ship's compass, and that experiment has fortunately now shown that with a well-designed installation all trouble may be avoided. It occurred to me, before I read this paper or came down here, that some better method of isolating the ship's compass might yet be discovered. If it had been, it no doubt would have been brought into use, but is there any likelihood of some mode being discovered by which you shall be able to isolate the ship's compass that it shall not be liable to be affected by external magnetic properties, and only the natural magnetic direction prevail? I think that it would be useful to myself and it may be to others that my question, though simple to him, should be answered by so experienced a lecturer.

Captain CURTIS: You can isolate electric wires by gutta-percha, but unless you can get transparent gutta-percha to see the compass through, I do not see how you can isolate it.[1]

The CHAIRMAN: Before asking the lecturer to answer the questions that have been put, I intended making a few remarks, but the wind has been taken out of my sails, for I think they have all been touched upon in the discussion. The first one simply was as to the possibility of having a reliable compass in a conning-tower or in a protected position to steer the ship by. In a ship of war the important point is the consideration of what may happen in action. The man at the wheel may be told to steer a course, but that is no use unless the compass is free from vibration from the concussion of gun-fire. He can see nothing from inside the conning-tower, even if there is no obscurity from smoke. Therefore he is solely dependent upon the compass. I quite concur that it is improbable that the Commanding Officer, under the fire of machine-guns and quick-firing guns, will be able to get at any other compass outside the conning-tower, if he does the chances are he will not get back again, and most probably he will find the compass destroyed. I dare say some of us here as midshipmen were very much puzzled in shaping a course between the variations to be allowed to the right and deviations to the left, &c., and when we had to pass examinations for Lieutenants, it was a stumbling block to a great many of us. It is a comfort to the younger members of our Service that it is quite possible nowadays that this may be removed, and we may have a tolerably permanent corrected compass to steer by. No doubt on the compass question the sea service of all countries is very much indebted to the inventive genius of Sir William Thomson. I am sorry he is not here to-day, because we should very much like to have heard him on this subject. The compass, as it appears to me, is the same as any other scientific instrument, there can be no finality in it, and we must go on improving. As time goes on, new discoveries are made in magnetism, and new inventions in construction, as in almost every other subject. Then we must remember this, that different compasses are required for different positions in a ship, and that one that would be suitable in the conning-tower probably would not be suitable outside. In the conning-tower, what with the iron walls surrounding it and the magnets required for compensation, it is a wonder to me that you can get the compass card to move at all. The directive force of it must be very high indeed to overcome all these difficulties. I think after all, the main point comes to this, that the whole question of compass designing and compass construction must be a matter for open competition. The inventive talent of the country must be called upon to combine with the experience of the sailor, and asked to advance. There are many marine instrument makers in England, and in compass construction competition is as important as in any other trade in the country.

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[1] At present no substance is known to isolate magnetism. Vibration or jarring has a remarkable effect in removing the "residual" magnetism of "soft iron."

I think it redounds to the credit of the Officers navigating our men-of-war that not more accidents occur through the error of the compasses.

I believe many merchant ships get embayed by shaping their course too fine from point to point at night, and run ashore, by the errors of the compass.

Staff Commander CREAK: I must first return my sincere thanks to the Hydrographer for his very kind remarks with regard to me in the matter we have discussed. As he has not made any special remarks except in support of my views, I have nothing to answer. I also thank Captain Mayes for his kind support. Admiral Colomb asked me one or two questions. One was about Gaussin's error; whether this difference of deviation resulting from swinging in opposite directions was due to Gaussin's error. It bears something of that character, but I really think it arises from the cause stated in the paper, though I am not quite satisfied with what I have said about it. A certain amount of iron in the ship parts with its magnetism instantly, the same as when you roll a soft iron sphere rapidly on a table, and no trace of magnetism is carried round with it; but there is another kind of iron in the ship which is not quite so soft, and takes some little time to part with its magnetism. I think that is really the cause of the deviation being different when swinging different ways. Then with regard to fog. The Captain of a merchant ship with whom I was once talking complained that he was constantly being troubled with the effect of fogs on his compass in the Baltic. I asked him to try it systematically, and to send me the result when he came back. He was to go to some place in the Baltic and lay alongside the quay; when there to note whether the compass altered after fog had come on, and then I should believe in it. He never could tell me such was the case. I found it simply arose from this fact: when they were steering up amongst the various islands in the Baltic, as long as it was clear weather, although the man at the helm often let the vessel fall off her course, the land being always in sight, the Captain could haul up a point or so, as required. After the fog came on the helmsman steered no better, whilst the Captain's corrective for the bad steering was no longer available, and the fog was blamed. I believe that is the sole cause. We know that the most delicately constructed instruments at Kew are in no way affected by the fog. Reflection applied to the compass is another question. I do not see how it is to be done. I think if you come to think of the smoke with which we should be surrounded in action, we should hardly see any reflection. Steam especially has a very bad effect upon all reflectors. They have often been proposed, but I can see no way to the use of reflectors. I quite agree with what Admiral Colomb said about the frequent corrections of the manœuvring compass, and the auxiliary compasses used for steering might be corrected as often as desired, and Commanding Officers should give an opportunity for it to be done. I know in some ships the complaint is made, "Why is the compass not correct?" and the answer has been, "You have not given me the opportunity of correcting it." The magnetism of the iron of a ship is liable to changes, and the deviation of the compass must change in obedience to them; therefore there must be constant correction. Captain Parr has made some well-deserved remarks about the instruction at Greenwich. I am glad to hear he is satisfied with it, and I dare say he will be ready for the next examination when it comes on. I must also thank Admiral Ommanney for his kind remarks about this paper. Respecting the change of magnetism of a ship, I must say that there is a definite character impressed upon her in building which is never lost. Admiral Brine asks about the heeling error. Perhaps I have not made myself perfectly clear on that question. What I mean is if you take the heeling error of 1° 10′ obtained for the standard compass of the "Orlando," by actual inclination of the ship for 1° either to starboard or port on north and south courses, then, if that ship were inclined 10°, there would be 11° 40′ of heeling error.

Admiral BRINE: That would be constant all through.

Captain CREAK: No, it would alter as the cosine of the azimuth of the ship's head, and would be zero at E. Take N.E., the intermediate point, for example, you would have to multiply the 11° 40′ by 0·7, and you would get as result a heeling error of about 8° 10′ on that point. I may say with regard to the remarkable disturbance of the compass at Cossack, Australia, that unfortunately the "Meda" did not return there, and therefore as full an examination of the spot was not made as was desirable, though the best was done in the time available. The whole of that part of Australia is very highly magnetic. There are ferruginous rocks in several parts of Australia; in fact one may observe the red lines passing through the sandstone rocks, many of them very highly magnetic. With regard

to the vertical force of these rocks where the compass is concerned, the only thing to be feared is a possible horizontal component to their total deflecting power. Captain Beall made some remarks about sub-permanent magnetism. The word "retentive" I have never taken to. "Retentive" means something that is kept, not parted with; but "retentive magnetism" in the way we see it described in the books is anything but retentive in the natural meaning of the word.

Captain BEALL: I say you call "permanent" what we call "retentive."

Captain CREAK: I am only speaking of the word "retentive." Now with regard to the word "sub-permanent" I think that is another matter, in which we must move a little with the times. When the Astronomer Royal adopted the word "sub-permanent" it was his opinion that the whole of the magnetism of the ship was more or less sub-permanent and not permanent. By the investigations I have shown in the early part of the paper almost the whole of the magnetism of our men-of-war is permanent, so why call it sub-permanent? I speak of sub-permanent magnetism which has the character of permanent magnetism in a measure, but is subject to constant change either from running on one course or from the blows of firing guns and various other causes. With regard to the heeling error caused by spheres, I have made experiments with $8\frac{1}{2}$-inch spheres attached to a Thomson binnacle, and found that if you incline that binnacle, for the first 5° of inclination there is a heeling error of 55′ for each degree of heel; for the first 10° about 50′, and if you incline it to 30° you will find it is 20′ for the last 5° of heel. I conclude, therefore, that whilst the heeling error is a constant quantity and goes on increasing equally for every degree of heel till 30° is reached, the effect of the globes as correctors is a diminishing quantity.

Captain BEALL: I understood Captain Creak to mean that, supposing for the sake of clearness the heeling error were a constant quantity, say 4°, then, if the vessel heeled over more than 5°, the spheres would not be so powerful, or in other words would not compensate the supposed constant error of 4°. But perhaps I may have misunderstood Captain Creak, and he means to convey that they decrease in power proportionately to the heel of the ship, but even then it would appear from the figures given in my remarks, which were obtained from actual experiment, that the decrease would in some cases be very small, if any. I found that spheres (about 4″) which corrected a $+D$ from athwartship iron alone, also just corrected the heeling error caused by the same iron up to 25° of heel; and no doubt would do so beyond that.

Captain CREAK: What I mean exactly is this, that the globes do not do as much work at the extreme heel of 30° or 40° as they do during the first 5°. Then, with regard to the point mentioned by Colonel Baylis, asking whether some insulating substance cannot be interposed to eliminate the magnetic effect of the ship on the compass; that has been tried by several people. Some have tried it by using soft iron and various other substances, but we know perfectly well it cannot be done. The directive power upon the compass is the earth, and we have already interposed between the compass and the earth a very big magnet and a lot of small magnets in the shape of a ship, and her fittings, as well as armour-plating of soft iron, which adds to the difficulty. I know of no substance which can be interposed between the compass and the ship which does not isolate it from the directive force of the earth. I am very glad to hear that our Chairman believes that there is no finality in the question of compasses, and that anybody, no matter who he may be, who will bring forward some improvement, should be courteously entertained and his proposals fully gone into, and, if good, adopted. I should not like to sit down without making one remark with regard to the Constructive Department of the Admiralty, and acknowledge the ready manner in which the Director of Naval Construction and his whole staff meet me in every way, by affording me every facility for carrying out experiments or desirable improvements in the disposition of the compasses in our ships. I have also to return my thanks for the kind attention with which my paper has been received.

The CHAIRMAN: I meant to have referred to the question of the reflector for compasses, raised by Admiral Colomb. I have had some experience with reflectors with reference to gun-fire, and found they were always dim on board ship and generally out of order. They have never been able to stand the shock of gun-fire.

I remember on one occasion at Shoeburyness the disappearing gun was being fired with reflecting sights. The captain of the gun looked up over head into the reflector which was above the parapet. The gun was fired and everybody looked out towards the target, 1,500 yards off, but instead of the shot striking the water near the target, we found the gun had been pointed about 45° to the left, and the shot had gone through the roof of a shed in that direction owing to the reflector having got disturbed. It now devolves upon me to return our thanks to the lecturer for his admirable lecture which had led to a very interesting discussion.

P.S.—I can bear testimony as to the efficiency of the liquid compass for boat service; forty years ago one liquid boat compass was supplied to the flag-ship on the West Coast of Africa. Boat cruizing after slaves was carried on to a considerable extent mostly out of sight of land. This liquid compass was the only one that was of any use when rowing hard or in a sea-way, all others would vibrate three or four points off the course each way.—H. B.

Wednesday, June 19, 1889.

REAR-ADMIRAL P. H. COLOMB, Member of Council, in the Chair.

THE MECHANICAL COALING OF STEAMERS.

By MR. JAMES RIGG, C.E.

BEING aware that the question as to the best method of coaling war steamers has already on more than one occasion been treated of and discussed at this Institution, I should not have ventured to offer the following observations and drawings for your consideration, were I not convinced that there is yet very much to be done in this matter before our Navy can be regarded as the perfect fighting machine that it might be if it could be kept continuously coaled, irrespective of proximity to coaling stations or ports. We are not about to consider abstract propositions, but rather definite and ascertained requirements, and the methods which I shall advocate have suggested themselves from an experience of many years in my business of a mechanical engineer, specially in the manufacture of machinery for loading coal under various conditions.

Though it is true that the great bulk of the coal-loading machines which I have constructed—upwards of 500 in number—have been for loading coal as received from the pit-shaft, the information obtained has a direct bearing upon this question of coaling steamers.

Three distinct sets of circumstances occur and have to be dealt with, and, though the necessary limit of time does not permit of my entering with such detail as might be desired, I hope to be able to make my proposals clear. They are to coal steamers as follows:—

First. At a station where the coal is received in railway trucks which must be raised to a sufficient elevation to enable them to discharge their load into the vessel to be coaled.

Secondly. From barges or lighters in smooth water.

Thirdly. From steam colliers.

Now, the object being to provide an expeditious and safe method of coaling under all the above-named conditions, the question may arise, what advantage is there in doing so when the bunkers frequently cannot take the coal so quickly as it can be placed on board? The reply to this is that the authorities will be satisfied in all cases if it is put on board overall, irrespective of the bunkers or their position, which latter is often regulated by more important considerations, but one rule in connection with them should never be departed from, viz., that the aperture for admission should be smaller than the trunk for

communication (where one exists), and that having once entered it must pass by the force of gravity alone into the bunker. The value of the coal as a source of protection is fully recognized, but though it is frequently necessarily placed in inconvenient positions, this is no reason why the above conditions as to its admission should not be fulfilled.

The problem for consideration is, therefore, simply one involving the delivery of the coal, under the various circumstances stated, overall, to be conveyed where the bunkers are not under the point of delivery, by the crew, and in the case of vessels constructed with side bunkers, into them direct, and, if possible, into both sides simultaneously.

The first system which I will describe is suited to many of our Colonies where coal has been discovered and is being worked, such as New South Wales, Nova Scotia, Natal, and New Zealand, in which latter Colony I suppose some of the finest seams in the world exist; and I observe from an article in the "Colliery Guardian" of the 10th May last, that some vessels of the Royal Navy recently in New Zealand waters were there coaled with such satisfaction to their Officers that it is probable that those on the China Station will in future receive their fuel from this Colony.

In illustration of the first system I give a general side elevation (Fig. 1) of a Portable Elevator for which I recently prepared the drawings and specification, and it is now being built in France by a French company for erection at Venezuela, and is to be used there mainly for coaling mail steamers, but also for loading coal cargoes. As a rule, one, or, at the utmost, two such elevators would be required at our various Colonies from which ships-of-war should be expeditiously coaled. As each elevator for this purpose must be self-contained and complete, the extensive systems of hydraulic tips, though admirably adapted for simultaneously coaling a number of vessels, are unsuitable in the present instance where it is only desired to coal one at a time.

With a view to simplify the matter and avoid the multiplication of drawings, I have given in this case one elevation only. (Fig. 1.)

The coal comes down from the collieries in metre-gauge end-door wagons of a gross load of 9 tons, viz., coal 6 tons and tare 3, and the machinery provides for this load being raised 33 feet.

The structure is rectangular in plan and about 65 feet in height, and carried upon twelve steel wheels, four on each of the outer rails at about 25 feet apart, and two each on the metre-gauge centre wagon road. The various motions are performed by a pair of vertical engines in the engine-room above. They include hauling the loaded wagon up hinged rails on to the tipping turntable platform within the elevator, the capstans for this purpose and for slewing the wagons athwart, as well as worm gearing for propelling the elevator along the pier to positions opposite the ship's bunkers, being driven by steel wire ropes from above. The elevation of the wagon is performed by the engines through mortice gear and two sets of worms and drums, the balanced platform being thus always suspended by duplicate sets

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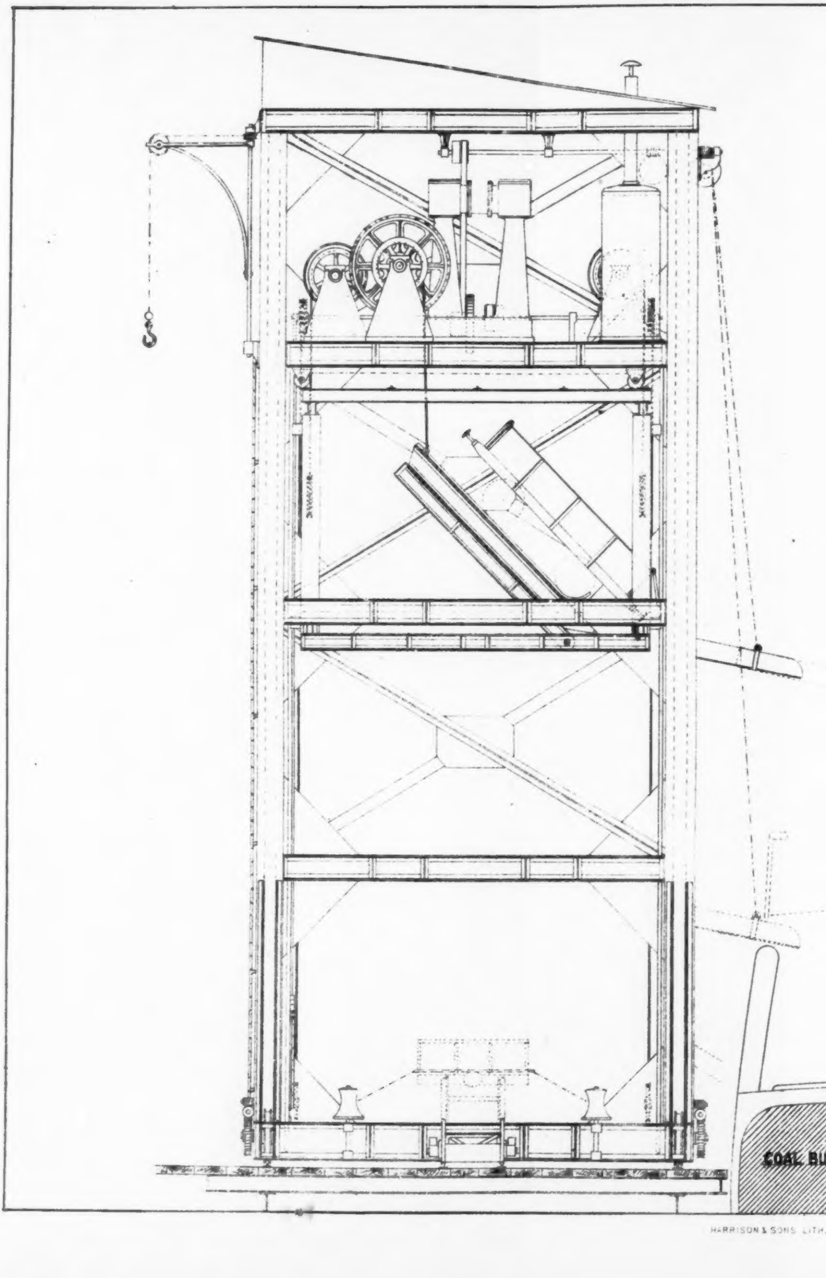
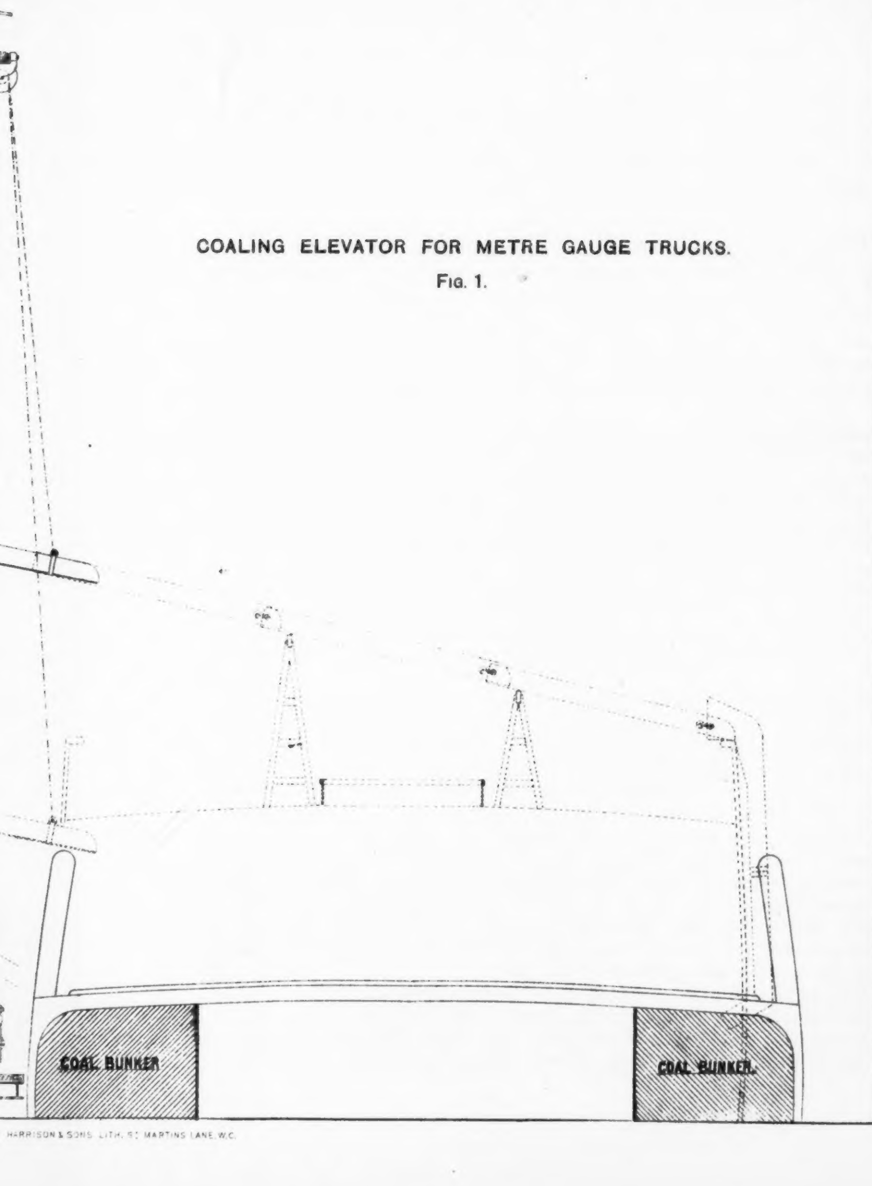


HARRISON & SONS LITH.

COALING ELEVATOR FOR METRE GAUGE TRUCKS.

FIG. 1.



HARRISON & SONS. LITH. ST MARTINS LANE, W.C.

of steel wire ropes, one pair continuing to support it in the event of breakage of the other. The wagon may be stopped at any elevation, and tipped by other gearing shown in the drawing, to 45°, which experience shows to be the correct angle of delivery for coal when loaded from end-door wagons.

The whole of the operations of raising, lowering, tipping, actuating inclined hinged rails, controlling an adjustable delivery shoot, propelling the elevator, and working the capstans are performed by the pair of engines, suitable clutches and levers being provided for all these motions. The engines are driven by a pair of vertical boilers, and the turntable platform is balanced by a series of cast-iron weights moving in slides, the main uprights and platework throughout being of steel riveted to steel angles. It will be observed that this arrangement of gearing provides for the wagon being stopped in any position of its ascent, and the short shoot may for a similar reason be placed at the height best suited to the varying freeboard of a vessel being coaled, or to her changing height from the pier dependent upon the state of the tide. The small jib-crane shown on the left is for raising coals and stores to the engine-room.

To illustrate the application of this elevator I have shown in full lines a midship section of H.M.S. "Leander," and above this in dotted lines a section of a mail steamer, and the method provided for delivering coal into bunkers on both sides.

The machinery of this elevator is calculated to raise and deliver coal from twenty of these 6-ton metre-gauge wagons, or 120 tons per hour, thus:—

Haul on to platform....	30	seconds.
Slew athwart	10	„
Raise (say 17 feet).....	35	„
Tip	10	„
Lower (17 feet)........	35	„
Slew fore and aft	10	„
Haul off	20	„
Time wasted	30	„
	180	seconds = 3 minutes.

Under ordinary circumstances it will thus be seen that an elevator of this construction will raise and deliver coal from an average height of 17 feet at 120 tons per hour, or a vessel taking 500 tons would be coaled in about four hours. The same system applied to 10-ton narrow gauge trucks would result in this quantity being put on board in two and a half hours. The engine driver controls all the motions, so that, after allowing for hooking on trucks, opening doors, &c., the cost per ton will be extremely small. The estimated weight of this elevator is 50 tons, and the provision of a means of self-propulsion enables it, when a steamer has been coaled, to be readily removed along the jetty, the rails upon which are thus available for goods trucks in connection with the loading and discharge of general cargo.

It should perhaps be mentioned that, to make the drawing more clear, the diagonal braces in front have been omitted.

In proceeding to the consideration of the second system, coaling from lighters, and the third, from steam colliers, in each of which I propose to employ a continuous succession of open buckets, or rather, trays, I would point out that the amount of coal delivered is not a measure of the capacity of the machinery employed, because coal cannot be taken up as grain and other substances are, but must be loaded by manual labour. This being so, the deductions that I have drawn are based upon the number of men for whom accommodation could be provided in the hold of the lighter or collier.

My system for discharging coal from barges on smooth water is shown in Figs. 2, 3, 4, 5, 6, and 7, and I was led to take up this subject on account of the expense, annoyance, and delay caused to shipowners, merchants, and others by passing coal, grain, and certain other descriptions of cargo in bags and baskets over the ship's side, and these objections have been by no means removed by substituting the employment of the ship's tackle in "whipping" this class of cargo on board by a means specially provided for the loading and discharge of packed merchandize.

That we may better know upon what we have to make improvement it will be convenient to refer to facts, and I have much pleasure in acknowledging statistics in Lieutenant Greet's paper,[1] read before this Institution on the 6th February last, as the source from whence the following calculations are made with reference to the methods of coaling in the recent naval manœuvres by bags, baskets, and by whipping.

For simplicity and comparison, I reduce the calculation to the amount of coal drawn from one hatch, and have taken the most favourable view. The coal was loaded from lighters at Plymouth, and a lighter and jetty at Portsmouth :—

"Agincourt,"	Plymouth,	500 tons,	12 hrs.,	or 1 hatch,	250 tons	$= 20\frac{1}{2}$ tons per hr.
"Iron Duke,"	,,	330 ,,	22 ,,	1 ,,	165 ,,	$= 7\frac{1}{2}$,,
Do.	Portsmouth,	55 ,,	$2\frac{1}{2}$,,	1 ,,	$27\frac{1}{2}$,,	$= 11$,,
						39

or an average pace of 13 tons per hour.

The machinery of this elevator is carried upon six pontoons, bolted together to make up two lengths each of about 60 feet by 6 feet in diameter; they support a deck about 74 feet in length by 24 feet beam. At the top of a central steel lattice tower is a head, which is capable of revolving upon a roller path.

Suspended from this head upon the tower are a pair of steel lattice girders, curved at their lower ends and connected together. Each girder contains an endless chain of elevator buckets or trays, and when not in use these suspended girders are stowed away fore and aft, as shown on the side elevation, Fig. 2, and end elevation, Fig. 3. A pair of winding engines is fitted with three sets of gearing, viz. :—

[1] See Journal, No. 147, page 69, *et seq.*

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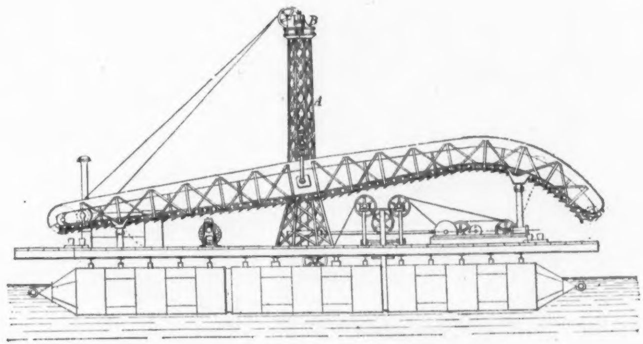
FLOATING ELEVATOR.

(Stowed away Fore and Aft.)

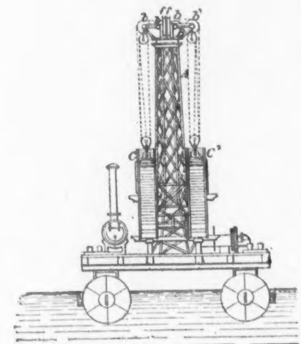
Side Elevation.

Fig. 2.



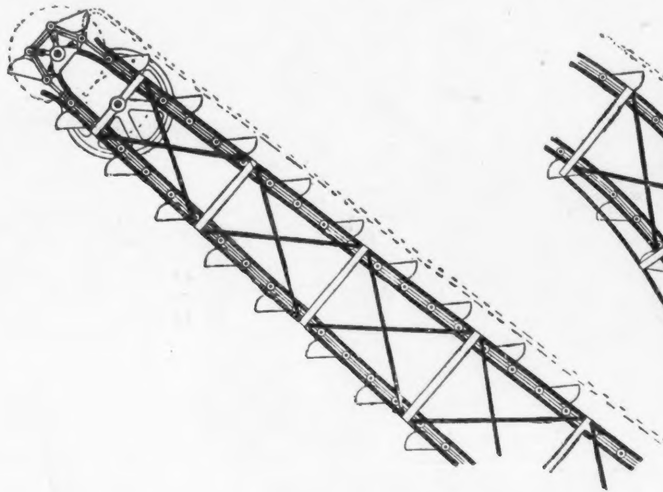
End Elevation.

Fig. 3.



COAL BUCKETS OR TRAYS.

Fig. 4.



GRAIN BUCKETS.

Fig. 5.

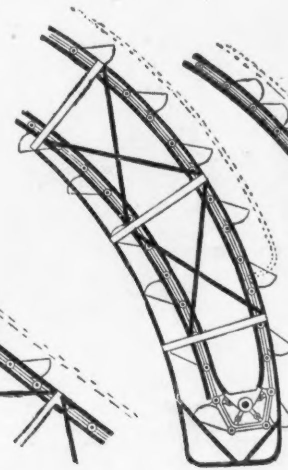
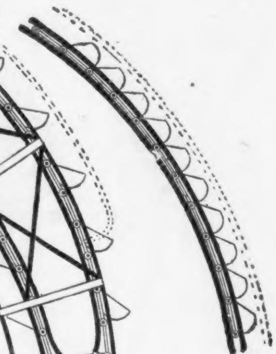
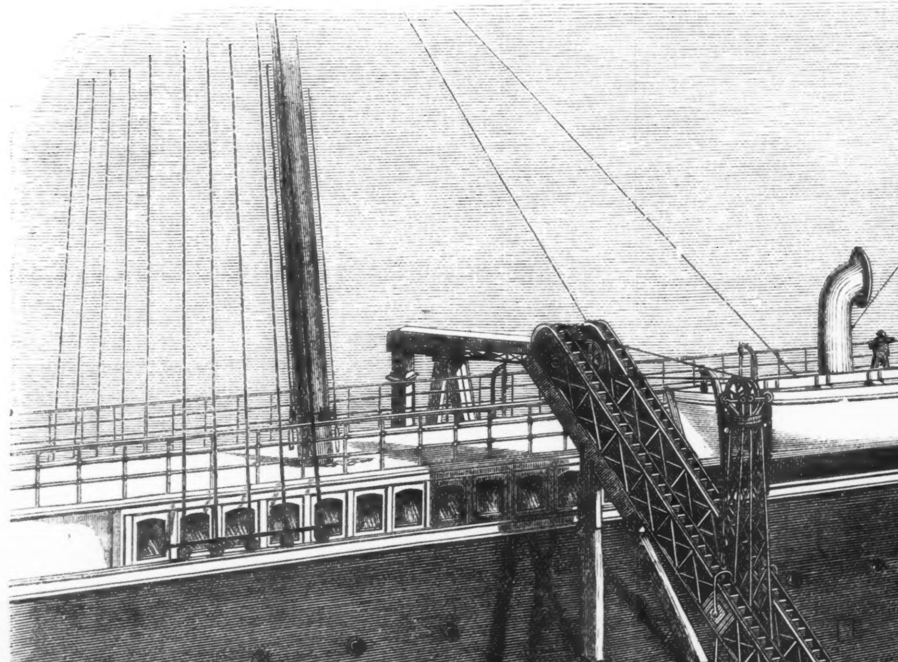


Fig. 6.



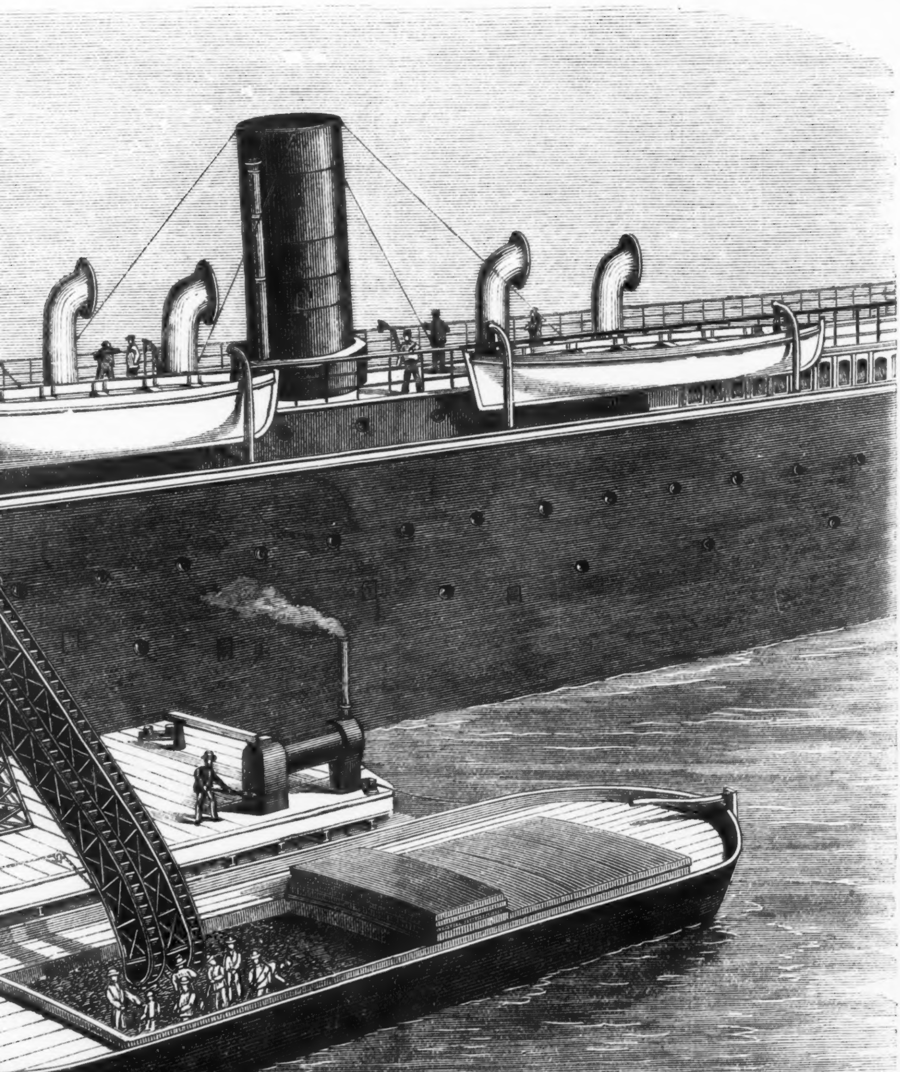
FLOATING ELEVATOR IN

Fig. 7,



LEVATOR IN OPERATION.

Fig. 7,



For raising and lowering the bucket girders.
For slewing them athwart; and
For driving an endless steel wire rope.

The form of trays which I prefer for coal are shown in Figs. 4 and 5, the first being the upper or delivery end, and the latter the receiving end, which dips into the hold of the lighter about to be discharged. The distinction between coal and grain buckets will be seen on reference to Fig. 6, this being the form adopted on one of these elevators, which I built for discharging grain from lighters at Sulina, on the Black Sea, where I found they took up and retained their charge until delivery at the upper end of the suspended girders into the steamer's hold.

Fig. 7 shows this elevator hauled up athwart the pontoon, and delivering coal into the side bunkers of a mail steamer. The grain elevator, when under pressure, as I mentioned on a former occasion at this Institution, was certified to have delivered grain at a pace of nearly 160 tons per hour, thus indicating the amount of work it is possible to transmit through a $\frac{7}{16}$-inch diameter steel wire rope, driven by a pair of 7-inch diameter cylinders. On the former occasion referred to I showed that men employed in coaling steamers by manual labour were capable of lifting 7 tons per hour, and these girders, accommodating eight men in their immediate proximity, would therefore result in one elevator placing on board 56 tons per hour, or if both sides could be coaled simultaneously, as in the case of the "Agincourt" at Plymouth, instead of occupying twelve hours in putting 500 tons on board, four of these floating elevators would have performed the work in less than two hours and a half.

To assist in arriving at a correct conclusion as to the policy of adopting a mechanical method for coaling steamers from the point of view of economy as well as expedition, I may perhaps be allowed to quote my statements in February last, giving the result of investigations I made into this question at Liverpool:—

Cost of Bunkering Coal with Patent Elevator.

	£	*s.*	*d.*		*s.*	*d.*
Engineer, per week	2	0	0			
Stoker	1	7	0			
Additional labour (two men)	2	10	0			
	5	17	0			
Depreciation, 10 per cent. on cost of elevator (£2,500) for one week	4	16	2			
Coal and stores per week (three working days)	3	5	0			
Filling—eight men, each 7 tons per hour = 56 tons per hour, or 560 tons in 10 hours (1 day) = 1,680 tons in 3 days at 1¼*d.* per ton	8	15	0			
Trimming—1,680 tons in bunkers at 2½*d.*	17	10	0			
Royalty on 1,680 tons at ½*d.*	3	10	0			
					per ton.	
	43	13	2	=	0	6¼
Present charge is 1,680 at 1*s.* 6*d.*	126	0	0	=	1	6
	82	6	10	=	0	11¾

The best gangs of coal stevedores having been thus found capable of lifting, each man, 7 tons of coal in sixty minutes, eight men, therefore, being a gang capable of working at these elevators, would result, as shown, in 1,680 tons being loaded in three days, and as each man employed received $1\frac{1}{4}d.$ per ton, the cost for the labour of the eight men only engaged upon this work in the lighter in connection with my elevator would be 8*l.* 15*s.* The charge by the stevedores was 1*s.* 6*d.* per ton, so that the economy resulting by the adoption of machinery would be 1*s.* per ton. On a single occasion of coaling a steamer taking 1,000 tons there would, therefore, be a saving of 50*l.*

If there should be any advocates of the intermittent system of "whipping" coal as compared with a continuous delivery from an endless chain of buckets, though the work was in grain, the following observation that I made when out in Sulina, has a direct bearing upon the question. Floating cranes were placed as my elevator is (Fig. 7), between the steamer and the lighter. Though the crane and bucket were worked with the utmost skill and under the most favourable circumstances, the quantity loaded was below 35 tons per hour.

With reference to the economy in bunkering coal by my elevator, as compared with the cost by manual labour, I have already shown that, whereas the cost by the former is about 6*d.*, the latter is 1*s.* 6*d.* per ton, and that my system, as compared with the present method, would deliver 56 tons instead of the average of 13 tons per hour over one hatch. The total weight of this elevator, with its pontoons and deck, was about 70 tons, and I should add that the perspective view appeared with a descriptive article in "Engineering," of the 28th July, 1882. The time occupied in changing from the position laid down fore and aft, as shown in Fig. 2, to that athwart and in operation as in Fig. 7, was under five minutes.

My third and most important proposal is to apply machinery to the discharge and transfer of coal direct from steam colliers, and if adopted would involve the abolition of the "bag and basket" system as well as that of "whipping." Before, however, considering it in detail, I am glad again to make use of figures in Lieutenant Greet's paper, showing what actually occurred in coaling from colliers at Lamlash during the naval manœuvres last summer. The statistics referred to the following seven vessels:—"Agincourt," "Shannon," "Iron Duke," "Tartar," "Neptune," "Inflexible," and "Inconstant." The work appears to have taken place in fine weather and under favourable circumstances.

The total weight put on board these seven vessels was 1,227 tons, and the time occupied seventy-two hours. As two winches and hatches were in operation the quantity will be halved, say 614 tons in seventy-two hours, being thus equal to about $8\frac{1}{2}$ tons into one hatch per hour.

It is now, I think, generally admitted that desirable and necessary as fortified coaling stations are, the present condition of naval warfare and this country's scattered interests throughout the world are such

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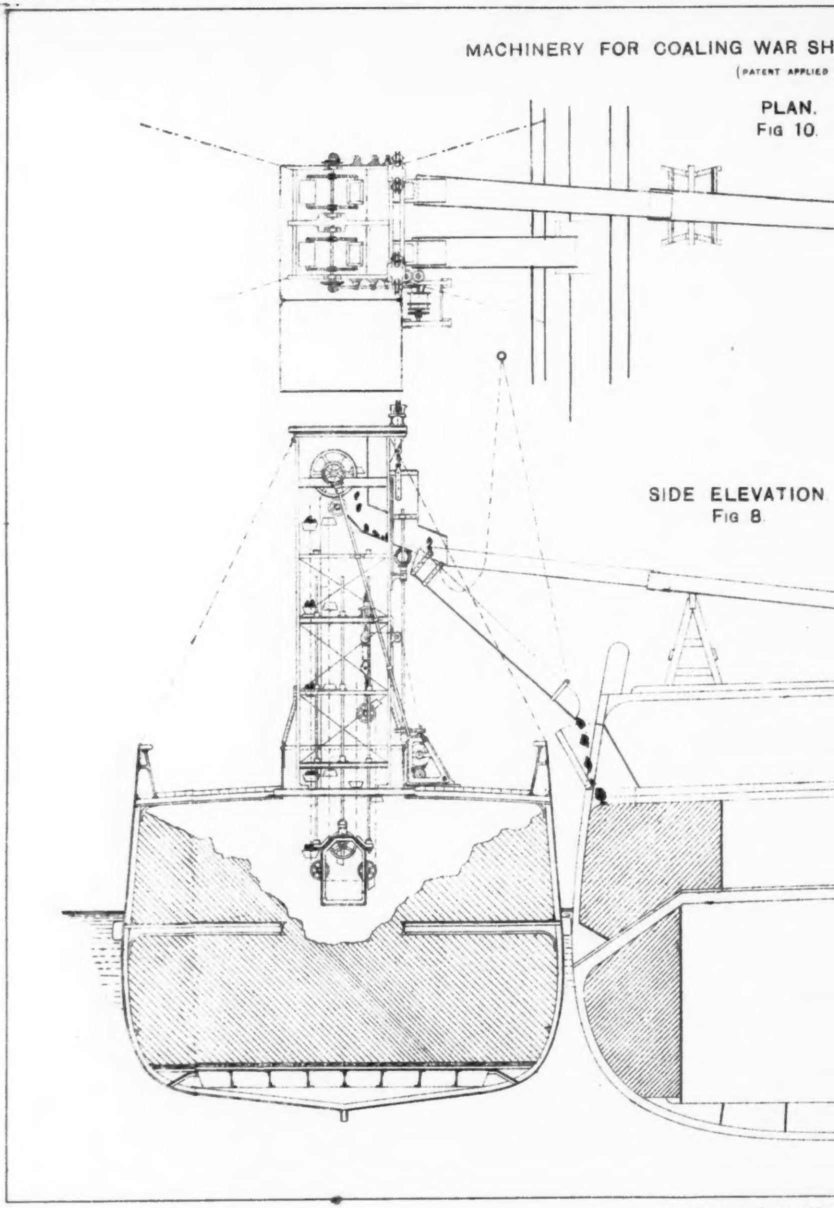
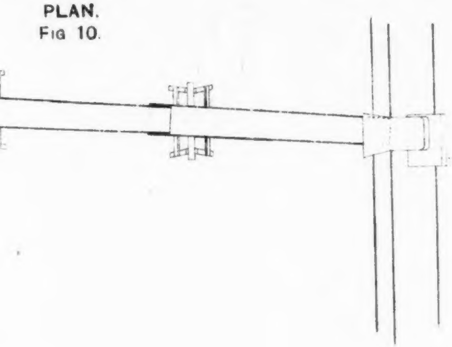


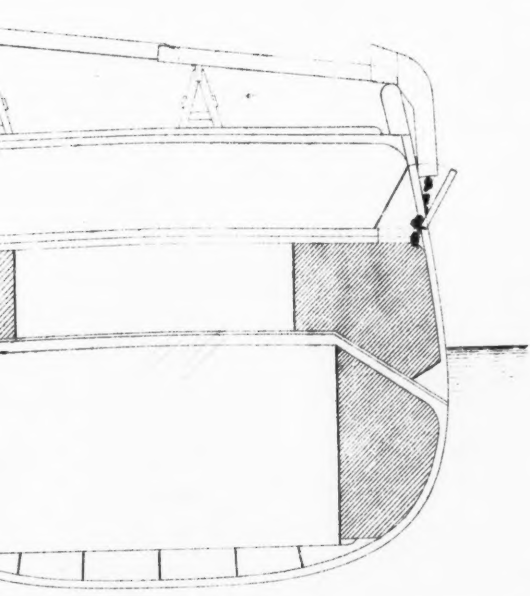
NG WAR SHIPS FROM STEAM COLLIERS.

(PATENT APPLIED FOR)

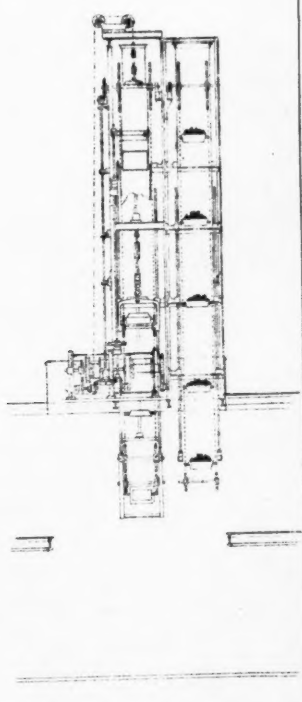
PLAN.
Fig 10.



ELEVATION.
Fig 8.



END ELEVATION AND SECTION
Fig 9.



that no multiplication of these stations will dispense with the need of one or more steam colliers accompanying every fleet.

I am well aware of the objection, by those most competent to form an opinion, to bringing a collier alongside the vessel to be coaled if in the open sea on account of the swell existing in circumstances of the greatest calm. It is, however, quite reasonable to suppose that any of the vessels of a fleet operating on an enemy's coast and desiring to coal could find sufficiently smooth water under an island or reef to permit of a prompt and efficacious mechanical discharge of coal from the collier with safety. If I am therefore able to demonstrate that such a method of coaling can be devised, any objection that hired colliers are not built of sufficient strength to meet such risks as there may be, is in itself a sufficient reason why the Government should build colliers of their own of suitable strength, since they are now admitted to be as much a necessity in naval warfare as the vessels they are required to coal. The tedious delay in coaling, such as was experienced last summer, would lead to almost certain disaster in actual warfare, and the quantity taken on board per hour is a clear indication that a change must be made and a method adopted to avoid this cause of danger.

We are thus brought to a description of my proposal as shown in Figs. 8 (side elevation), 9 (front elevation and section), and 10 (a plan). This is an elevator of a sufficient height to deliver coal on to the spar-deck of H.M.S. "Mersey," of which a midship section is given with side-bunkers, both this and the section of the "Leander," shown in Fig. 1, being taken from the illustrations given in Lord Brassey's "Naval Annual" for 1887.

I propose to employ ordinary steam colliers of modern design and the best construction, and permanently to place over the hatches of each hold either one or a pair of light open angle steel frames, suitably braced and tied. A pair of chain-pulleys on fixed bearings near the top of this frame sustain an endless chain of coal-buckets or trays. These trays, in the manner most clearly apparent in the side elevation (Fig. 8), at the lower end pass over other pulleys carried by a frame which is capable of sliding up or down, being at their highest point when there is a full cargo. The return end of the chain of buckets is capable of being readily lowered down or hauled up, thus enabling them to follow the surface of the cargo as the vessel is being discharged, and to be at all times within convenient reach of the men who must be in the hold to fill them. In front of the permanent delivery-bonnet, which receives coal from the trays or buckets, is a short shoot which is capable of sliding vertically within the limits necessary to meet the varying relative heights of the war-vessel being coaled and the collier, as she may be loaded or light. Through a suitable arrangement of gearing and clutches, one of the ship's winches will be utilized for all the purposes of driving the elevator, raising or lowering either it or the sliding shoot, already referred to, or driving a "conveyor" belt should it be desired to use one for the transfer of coal across the ship. The light shoot would be placed in position by the collier's tackle, and thus suspended from a boom.

These elevators may be worked singly, but I propose placing two of them side by side, as shown in Figs. 9 and 10, occupying at least half the hatch. Being worked by one winch and in one hatch, I treat them as one, the various motions being set in and out of gear by means of clutches on the main shaft from the winch.

Though I have shown that it is possible by this arrangement of machinery to deliver simultaneously into both sides of the vessel, it would rarely be done, because this can only occur in port, and these colliers are specially intended for employment under other circumstances, as already described; moreover, a rapid delivery of coal overall on to the deck will be accepted, as previously stated. The frames are open, and, being of steel, are extremely light, and therefore offering but little resistance to the wind, and not likely to affect the sea-going qualities of the colliers. The expense of fitting double elevators as shown in the drawings, *i.e.*, two in the fore and two in the after hold, might be taken approximately at 600*l.* to 700*l.*

As in the last case provision exists for eight men loading, and the vessel receiving coal would therefore do so at the rate of 56 tons per hour instead of about $8\frac{1}{2}$ tons, and steam in the winch boiler naturally being up when she came alongside, she might commence delivery within five minutes of such assistance being put on board from the crew of the war-ship as might be desired to facilitate loading the elevator-buckets. Assuming this vessel to be one of a blockading squadron, and that she took 800 tons, one of these colliers, working both holds at 112 tons as against the present method of loading, 17 tons in two hatches, would perform the work and release the vessel for duty in about seven hours as against almost seven times that period, or forty-one hours. For this purpose the buckets or trays might be about 22 inches by 16 inches, and thus capable of taking from 35 to 40 lbs. of coal, or rather under a cubic foot each. Being speeded to pass thirty-one up each elevator frame per minute, the capacity afforded would be about 10 per cent. more than needed to deliver at 56 tons per hour; and if I have thus satisfied you that this can be accomplished, it is all that I desire.

Among the minor, but at the same time important advantages attending a system of coaling by steam-power is, that the crews of both vessels employed would thus be relieved of a large amount of work which must be of an uncongenial character in either wet weather or in fine, or in time of peace or of war.

Captain CURTIS: I think we are all indebted to Mr. Rigg for his valuable paper. He has had great experience of practical work in coaling ships and therefore speaks with great authority on the subject. I am of opinion it is a matter that this nation ought to have taken in hand long ago. Mr. Rigg has not done himself justice. He gives himself credit of saving only $11\frac{3}{4}$*d.* a ton for coaling ships, whereas there is also the difference in the value of the ship's service and of the men between seven hours and forty-one hours. He states that he can coal a vessel in seven hours, whereas they now take forty-one hours to put the same amount of coal on board.

Mr. RIGG: The value of the ship certainly must be credited.

Captain CURTIS: In 1851 I went out to Rio, and the method of coaling at the Cape de Verde Islands was the collier discharged into lighters. If the vessel or

mail steamer was not there—they even had not steam lighters in those days—the coal was transferred from these lighters on women's heads and put on shore, and when a vessel wanted to coal the women picked the coal up again and put it into the lighters, and it was transferred from the lighters again to the steamers. Afterwards wheelbarrows were used, the women at first put the coals and wheelbarrows on their heads, until they could use the barrows properly. That could not be an economical way of coaling. Mr. Rigg says it is not necessary that the shoot should be at an angle of 45°. That upper shoot does not appear to me to be at an angle of 45°, and the coal would not appear to deliver itself in that slope by the laws of gravity. Grain, I think, will deliver itself at about 67° of angle. There is another point of great difficulty. In King's Lynn, where they discharge vessels with grain they have what they call meters—a man who has to weigh every sack of corn—and then it is discharged on to a driven belt somewhat horizontal, and the belt delivers it on to an up-and-down endless belt with buckets, and the corn can be taken to any part of the store they like. I am not sufficiently acquainted with the theory of the horizontal belt to explain it, but the grain always keeps in the middle of the belt. That is one of the difficulties I fancy of discharging by machinery, to know what quantity of coal the engineer gets and its weight, and also so with grain. I am sure that at Rio, where the unfortunate seamen have to whip the coals out of the ships without any awning, it would be a blessing to have one of these machines, and it would pay very well. Do I understand it is a fixture; or can it be elevated to any point you like?

Mr. Rigg: It can be elevated as shown in Fig. 7. There is a perspective view of it.

Captain Curtis: I think the whole thing is very ingenious. When you come to work it there would perhaps be certain improvements required which no doubt you would be able to meet. I think if a company were got up at once to work these machines it would pay, save demurrage and cost of labour.

Sir Edward Reed, K.C.B., M.P.: Admiral Colomb and gentlemen, I did not come here to offer any remarks upon this subject, but having failed to get time to read the paper over before the meeting, I came to hear it read. It strikes me that the remark which just fell from the gallant Officer was a very true one—that this is a very much neglected subject. It would hardly be proper here and to-day to consider why that is the case, but I fancy it does point to a very great deficiency that has existed in the management of the Royal Navy up to the present time, namely, that there appears to have been no one charged with mechanical operations other than certain limited and defined ones. This is a mechanical matter lying outside the ordinary duties of the only mechanical department of the Admiralty that I know of, and therefore I suppose it is that it has been very much neglected. Probably it is due to the fact also that naval Officers are so extraordinarily modest that they do not like to go an inch outside of their own immediate sphere, and to meddle with mechanical matters at all. At the same time I believe it to be perfectly true that this is a matter which has been frightfully neglected to the enormous disadvantage of the Naval Service, and to a disadvantage which might be immeasurable in time of war. Coming now to the proposals of the paper, they are obviously three in number, and wholly distinct. So far as the first proposal is concerned, that is, for providing movable elevators on shore in the Colonies and other places for the purpose of lifting coal trucks and discharging coal into vessels, that appears to me to be highly appropriate. It is well known to the author of the paper of course as to most of you gentlemen, if not all, that the system of raising the truck and tipping the coal from it is an operation carried on on an enormous scale at Cardiff; and also on a large scale at many other places. It may not be known to you all, however, that the method of moving the elevator on the wheels and rails as proposed here is also in use there. But all those operations are conducted, I believe I am right in saying, in Cardiff and elsewhere, by hydraulic power. Now hydraulic power is an invaluable thing when you can employ it for a number of purposes, and have a large and powerful plant from which you can distribute power over a large area; but Mr. Rigg proposes to deal with cases in which that would not be practical or economical, and, so far as I can see, his combination of machinery and his elevator for accomplishing the purpose is entirely satisfactory. I can see no fault

with it whatever, and although this is a matter I have had occasion to consider more than once, in so far as hydraulic arrangements go, I do not see any addition to make by way of improving his apparatus. I think very much the same might be said of the second proposal, for getting coal from lighters on board ship. Nothing can be more primitive or less satisfactory perhaps than the present system of dealing with coal. But neither of these after all is the great question that will press upon us in the Naval Service during war; it is the coaling of the ships away from the coaling stations; that is the real crux of the situation. Although I agree with the gallant Officer that a company for carrying out these various proposals might be a very successful thing, I am bound to say that I very much doubt whether it would derive any part of its success from the proposal with regard to coaling ships at sea. At any rate I do not see my way to anticipating much from that. In the first place the author speaks of a collier attending the fleet, but what is the good of one collier attending a fleet when that fleet is in active movement? It appears to me you would want a crowd of colliers attending a fleet if you are to keep the Navy coaled at sea. The author does not profess, and if he did profess I venture to think, although not a sailor, that he would make a great mistake, he does not profess to think that his method would be a satisfactory one for coaling ships from a collier at sea. He recognizes what must be familiar to every naval Officer, that the days at sea in which two ships could lie alongside of each other upon the open ocean, for the purpose here in view, must be rare days indeed. The condition of two separate vessels being so brought together is one that no one would like to depend upon, and therefore he says, and here I think he makes a little light of the difficulty—I am sure he will forgive me for speaking plainly what strikes me about the matter—he seems to make rather light of the difficulty because he says, "It is quite reasonable to suppose that any of the vessels of a fleet operating on an enemy's coast, and desiring to coal, could find sufficiently smooth water under an island or reef to permit of a prompt and efficacious mechanical discharge of coal from the collier with safety." Now I fear that in the most important condition of all, that of blockading an enemy's port, it would be an extremely difficult matter when the fleet has run short of coal to find a convenient island or reef under the protection of which you could run for the purpose of taking on board coal from the collier by the arrangement here proposed. To my mind some totally different system of coaling ships will have to be adopted before the Navy can be efficiently coaled at sea. I cannot say that I myself see any mode so satisfactory as to justify me in mentioning it here, but I do not believe for one moment that the solution of the problem is to be found in merely fitting the high elevator to be driven by the ship's windlass on board ordinary colliers, or even on board special colliers. I am rather inclined to think of some mode of coaling which would enable the one ship to throw overboard a large quantity of coal capable of being laid hold of by the ship that wanted it, and to be lifted on board by her own power; something of that kind which will not involve the actual bringing together of two patients into close comtact may be found. I have had a thought of that sort, tending in that direction, but I have not gone into it sufficiently. I am not quite certain that the difficulty of bringing two ships together and keeping them firmly by the side of each other, even in a considerable swell or sea-way, is one which could not be overcome by appropriate means. If it could, then the employment of such a steam elevator as the author proposes would be no doubt a very satisfactory method of getting coal from the collier to the ship. But I need not say to naval Officers that those means of one ship taking hold of the other and combining the two together for a purpose of this kind for a number of hours must be very ample, and must be such as to give perfect mastery of the circumstances, otherwise those appliances would very soon be disposed of at the first attempt to use them at sea. I do not know whether before a more satisfactory mode of coaling at sea is discovered, a more satisfactory mode of dealing with the fires of ships will not be discovered. It appears to me most of this difficulty arises from the great necessity of dealing with coal in the way in which we do deal with it in the feeding of furnaces. Under our present system one of the great objects in order to avoid injury and deterioration of coal is to keep it as large as possible from the moment you begin to attack it in the mine till you get it into the ship's stokehole,

and then you have to feed it in the manner well known to you. I think myself that some method of reducing the coal to dust and making it a semifluid material, dealing with it in that form, will probably facilitate the transfer into ships at sea. I leave it to naval Officers to speak as to the desirability and importance of that. I confess for my part the Naval Service seems to be so dealt with now as to make it vastly more desirable than ever it has been to obtain some means of coaling ships at sea, because of the extraordinary reduction in the proportion of coal supplies with which the Navy is being made familiar. It is well known that although much has been done to economize fuel, the proportion of fuel carried in the Navy now to power developed, is so very small, even as compared with the days when it was everywhere thought very small, that I can hardly understand how we can expect our great and costly vessels to perform that service to the country which we should naturally expect of them after spending a million of money on a single ship. I hardly see how they are to perform that service with anything like continuity or efficiency with the small coal supply which they now carry unless some method of supplying them at sea is provided. I wish I could have believed that with respect to this third operation the author of the paper had been as successful as I consider he undoubtedly has been in the other two cases, but I cannot feel that that is so. I still feel that the problem of coaling our men-of-war at sea is unsolved.

Captain MACLEAR, R.N.: I am sure we are all agreed that the difficulty of coaling is a weak part of our naval power, and all naval Officers will welcome most heartily anything that can tend to remove that difficulty. I will only at this moment deal with one or two things that struck me about the method of coaling from colliers, which is admirable in theory; but we must recollect that there is always a motion of the ship backwards and forwards, the ship or collier will be always forging ahead and there will be a roll. And we must not expect that anything so rigid as that shoot appears to be will be able to keep up a continuous supply of coal, it will frequently have to be adjusted, and therefore it will not be able to supply the ship in the time that it would if it were on shore or in the basin. I think the quickest coaling in the world is done at Aden by men, and the very reason of the rapidity of coaling there is the pliability and adaptability of the men and the small baskets; they can be directed to any part of the ship at once, wherever it is wanted. In men-of-war, especially, we have a number of small bunkers distributed everywhere about the ship. We cannot, therefore, supply the coal in one mass on the deck; it will have to be distributed over a large surface and quickly stowed. There is our difficulty. Therefore I think one or two tubes, delivering in only one or two parts of the deck, will not coal a ship in the time that would be effected in a basin, and with wide open bunkers. For rapid coaling we require a small stream of coal directed to each bunker hole.

Mr. HENRY ADAMS: Although this subject is of much interest and importance, it is one rather difficult to discuss, because the special features of the author's proposals have not yet been put to the test of actual work in coaling ships afloat. I have had considerable experience in the working of machinery for handling coal, including one-third of the seaborne coal brought into the port of London during the last twelve years, and I know the many difficulties that there are in manipulating it. Welsh coal, particularly, is a most unmanageable material; you find in it lumps varying from 1 to 2 cwt., or more, and in some instances I have known lumps measuring 2 feet high, which have become blocked under the yoke of the shoot and prevented the run of the coal. If the coal were at all approaching the character of grain all difficulties would vanish: it would be dealt with as readily as oil or other liquid fuel might be. Another point with regard to handling coal is the hulk out of which it may be taken. The time occupied in delivering any quantity of coal depends very considerably upon the hulk at which you are working: for instance, in unloading 60-ton barges by crane, the best work averages only 3½ tons per man per working hour, exclusive of the time occupied in shifting the barges. But, as showing what coal fillers can do, on the 21st of January last, at the Royal Victoria Docks, London, one gang of eight men at one crane discharging from a screw collier (s.s. "Dawdon") delivered 641 tons of gas coal in twelve hours, except a small quantity of 45 tons done by another gang while the first gang was at dinner. That equals 6½ tons per man per hour in long-continued work, while over

a short period of two or three hours about 8 tons per man per hour can be done; so that the author is probably within the mark in saying that 7 tons per man per hour can be loaded if the circumstances are sufficiently favourable. With regard to this arrangement for the coaling of ships from steam colliers, I do not quite see how the coal is to be brought from the ends and corners of the holds to the elevator. To trim from those points by hand would be almost an impossibility at anything like reasonable cost. As to the angles of the shoot, it is found that 36° is the minimum at which shoots can be depended upon to deliver coal in all weathers. I think the author deserves great credit for the time he has spent upon his paper and the ingenuity he has shown in his designs, and I thank him for the opportunity of being here this afternoon.

Captain CURTIS: I might say it was not unusual in the French war for transports to unload alongside sailing vessels, but then the ships could form a lee with their sails to keep the ships steady.

The CHAIRMAN (Admiral Colomb): It is usual before calling upon the reader of the paper to answer the questions that have been put, and to offer his explanations, for the Chairman to make some remarks upon the paper and upon the discussion. My own view of the value of this paper is that it is from a gentleman who is very well acquainted with the moving of coal. We may have speculative papers here sometimes on these questions, but so far as Mr. Rigg is dealing with the question now, he is dealing with what he really understands, and therefore I think it is a very good thing, even if it went no further, that we should have the paper of such a gentleman in the pages of our Journal. I think myself that, considering that the mass of our coaling at home in European waters has to be done through the double process of emptying coal into bags and then emptying it again out of those bags, or, in case of colliers alongside ships, that we have to fill the bags on board the collier and pass them filled into the man-of-war, and then distribute them afterwards and empty them, it seems almost obvious that any appliances which tend towards getting rid of these processes tend towards a proper result. And I cannot help thinking that, even so far as the elevator shown on Diagram 7 goes, it is not at all impossible that simply as a matter of economy, without going into the question of speed, for Portsmouth and Plymouth, for instance, a great deal of economy might be reached by means of one of those elevators. Instead of, as at present, passing the coal into lighters in bags and then into the ship in bags, and then emptying them again afterwards, it would be only necessary to discharge the loose coal into the lighters in the harbour, to tow out the lighters and elevator alongside the ships in the Sound and at Spithead. I take it it is quite on the cards that a considerable economy, both in money and time, might be effected. The cost of the apparatus, as far as I understand, is not anything very serious. Coming to Diagram 8, which is, of course, the crucial one, I think myself that there is something in what the lecturer has said as to the possibility of coaling on an enemy's coast when the process is quick. If it were a very long process it might be difficult for one of our ships to take a collier and go into such smooth water as is to be obtained on an enemy's coast, under islands and headlands, and so on—it might be difficult to undertake that because we might suppose that the enemy would have time to bring down guns or something to annoy you in the process. But if it should turn out that, by appliances of this kind, coaling where smooth water is required could be done with great rapidity—in a very short time—I conceive that it is a thing that might be attempted. We should chance it that the enemy would not be able to bring guns down in the time, and that the coaling would be done before they could do so. But of course that is more or less speculative. But there is certainly that clear point which we got hold of in the manœuvres last year, and that is that either you will require for our fleets, even for that sort of work, a number of smaller colliers, or else that the large colliers must be furnished with some means of much more rapidly discharging than they have at present. And it is quite a question, in my mind, whether, considering that the cost of an apparatus of this kind would not be very great, whether it would not be worth spending 800*l.* or 1,000*l.*, or whatever it might be, to carry out that experiment, to see how far that rapidity of work which the lecturer promises might be got at. I think that is the way we have to look at it. We cannot expect to jump to conclusions on these matters. It must be done tentatively, and when you

have a paper of this sort from a gentleman who is practically acquainted with the matter and has made the machines which he proposes to modify for coal, it is worth while thinking as to proceeding to experiment with it. I shall now ask the lecturer to answer the questions which have been put to him.

Mr. RIGG: I will take the questions that have been raised in the order in which they occur. With regard to that of the ship's time, undoubtedly credit must be given for economy in that respect, and it is considerable in large vessels. In merchant vessels it might be accepted as about 30*l.* a-day, and I have taken no credit on that account, but have simply dealt with the financial aspect of the question as influenced by labour and the introduction of machinery, and as this immediately affected the coal that had to be handled. With reference to the shoot shown in the Diagram, Fig. 8, Captain Curtis observed, I think, that it was at an insufficient angle to deliver by gravity. That is perfectly true, but my statement in this paper was, and experience has proved it over and over again, that an angle of 45° is the one for the delivery of coal from end-door railway wagons. Coal will not leave at 40°, but it passes freely from the wooden floor of a wagon at 45°. This, however, does not apply to these shoots, which are of steel, and I might enter into questions of minor detail upon these angles, but this would not perhaps now be to the point; they are less than 45°, and I think I can confirm Mr. Adams's remark from experience that coal loaded under these circumstances would pass well at 36°, when it has an impetus at the head as upon leaving a wagon. Of coal screens I have made very many at about 32°. The question of this angle is of the utmost importance.[1] With reference to the "conveyor" or "belt," I am quite familiar with these. They work very well in grain and there are many of them, those who employ them having extremely good reason to appreciate their value. They perform their work with the utmost success for grain, but I am not aware that canvas belts are used for coal, nor do I think that they would be suitable. I know cases where wire rope belts are employed, and many others at collieries in the Midlands and South Wales where flat-linked chain belts of iron and steel plates are used, passing over drums for conveying coal to considerable distances from screens for delivery into boats and railway trucks; they work very well. I quite appreciate Sir Edward Reed's observations with regard to the first and the second of the methods which I have described, and in answer to a question that has been raised with reference to their actual employment and that they were arrangements or contrivances or proposals, I would again mention that this second has been in actual operation, and here is a photograph of one I sent out to the Black Sea. It is not, therefore, simply a proposal or scheme, and the statements made are facts and not merely calculations, but results based upon observations I have made when on board this elevator on various occasions. The principal difficulty, I think, which Sir Edward Reed indicated was one rather that affected the question of bringing one vessel alongside another. It was not so much a criticism of my proposal here to raise coal by mechanical means, which I believe to be extremely economical in consequence of the ship's winch performing the work, I have no kind of doubt, because the engines on board this elevator were the same size as nine out of ten of the steam winches which would be found ready at once for application to this arrangement of gearing, which I could not in greater detail show in these general drawings. I have no doubt whatever that the ordinary winches will be found capable of driving these elevators. Upon the question of coming alongside I confess I do not feel myself competent, in the presence of so many naval Officers, or even in their absence, to form an opinion upon this matter, or to contend against an opinion opposing the suggestion. But if there is nothing better before the country than the proposal I make here, why should it not be adopted? I think that criticism of this should be accompanied by a suggestion of something better. I mean with regard to the bringing of vessels alongside each other in comparatively smooth water, as described. It is quite true that if no substantial objection is raised to what I will call my mechanical proposal, there will be no difficulty at all in prolonging this shoot considerably, so that the vessels should not

[1] A reference made to drawings since this discussion took place shows that the average angle best suited to fixed screens at collieries is 22°.—J. R.

be allowed to come so near to each other. They might be some considerable distance apart and we could still put the coal on board and use the machinery exactly as I have provided, if there is any real objection to bring vessels alongside in that manner. I have very little doubt, and many others are of the same opinion, that liquid fuel will eventually be adopted in the Navy, but surely that is no reason why an efficient method should not be applied to the coaling of the Navy as we have it. We have not now a liquid fuel Navy, but one which takes coal on board, and under circumstances of considerable difficulty. Our object is to facilitate the method by which the coal is put on board. It is not before us now to consider the best method of putting liquid fuel on board, therefore I think it is premature to consider that, and a discussion of that question at the present time will not advance the matter. The importance of this question has been acknowledged generally, as well as by this meeting. Now, with reference to a remark from Captain Maclear about the question of carrying the coal across a ship. This illustration (Fig. 8) that I have prepared is not for one moment to imply that this collier shall be used for this purpose, except ing if she were in port: but she is not in port: it is merely intended to show that it could be done if she were. This long shoot might have been shown in dotted lines, and such importance would not then have been attached to it as has been since it appears in full lines. I further understood that Captain Maclear had an objection to placing the coal on the deck of the vessel, because it was desirable that it should be received in different bunkers at the same time. No doubt it is very desirable, and I have provided a means of putting it on to four parts of the vessel simultaneously from one of these steam colliers, two elevators being placed in the forward and two in the after holds, and there is no doubt that there should be more than one collier—two, three, or four, or a number corresponding to the vessels in the fleet. Now, assuming that two of these steam colliers are placed one on either side of a man-of-war (Figs. 9 and 10), each elevator is a separate and distinct machine, and it can be set independently in operation by means of clutches upon the same shaft, thus. There are two clutches upon the shaft for driving the two elevators: one is delivering into one part of the ship, and there is no reason why the shoot attached to the next elevator should not deliver into another part of the vessel. The South Wales coal, which Mr. Adams referred to, is larger than any other coal in the country. I am very familiar with it, and if these elevators were adopted, though we readily acknowledge the importance and necessity of keeping the coal as large as possible, because it drops to about one-sixth of its value when reduced to slack, it would be absolutely necessary, if this mechanical method of loading is adopted, to deliver the coal on board the colliers something smaller than the pieces which I have seen in Glamorganshire and the South Wales coal district generally—it would have to be delivered of a size that could be loaded into the elevator buckets or trays. I am extremely glad to find the confirmation which Mr. Adams's experience at the London Docks gives of the information I obtained as to loading coal per man in Liverpool; the quantities are evidently about right. The Chairman suggested that the floating elevator might with advantage be used at Portsmouth. Though I am not well acquainted with that place, I should think, from the calculations based on these statistics, that is exactly a case for one or more. If coal is there loaded from lighters there is no kind of doubt that an elevator could be adopted, and that there would be a very great economy in its use. I am much obliged to you for having listened to the paper and to the observations I have now made.

The CHAIRMAN: It is now my pleasing duty to ask you to return your thanks to the lecturer for his excellent paper. We are always very gratified when the outside world, as it were, come to enlighten us on subjects which they themselves are more closely conversant with than we are.

Wednesday, July 3, 1889.

GENERAL THE RIGHT HON. VISCOUNT WOLSELEY, K.P., G.C.B., G.C.M.G., &c., &c., Adjutant-General to the Forces, in the Chair.

THE PNEUMATIC TORPEDO-GUN; ITS USES ASHORE AND AFLOAT.

By Captain E. L. ZALINSKI, 5th Artillery U.S. Army.

The CHAIRMAN: I think we really owe Captain Zalinski an apology for the smallness of the audience. It is not often that we have to find fault with those who direct the affairs of this Institution. But, I think, in the present instance they are somewhat, if not very much, to blame, for not having postponed this lecture until after the Shah's visit to the City had taken place, and the various ceremonies that are to occupy this week had been got through. I am quite certain, had it been any ordinary time, Captain Zalinski would have had a very crowded hall to lecture to, and, for myself, I am sure I echo the feelings of all who take an interest in this very important subject, when I say that I hope that he will pardon the Institution for the small audience that he is called upon to speak before this afternoon. I have no doubt that all present know Captain Zalinski well by name, although you may not have had the honour and pleasure of meeting him before, I feel that he deserves a warm and cordial reception from the Officers of the Army and Navy, and from all the members of this Institution for many reasons; first of all because he is an Officer in the Army of the United States, secondly, because he is the inventor of a very wonderful implement of war, which most probably is destined to certainly influence, if not revolutionize, warfare in future, both on land and sea. But still more he deserves our cordial greeting because he comes from a kindred nation on the other side of the Atlantic, and we are always prepared here and elsewhere in all societies where English gentlemen meet together, to offer to all that come from thence a cordial and hearty welcome.[1]

COINCIDENT with advances in the arts of civilization we find rapid advances in the arts of destruction. Appliances for attack are met by new defensive appliances, and these again by more powerful instruments of destruction. Neither the attack nor the defence are long permitted to retain an absolute superiority.

At the present date the gun has practically overpowered the armour which may be carried afloat. The portion of a ship which can be protected from the high-power guns of even medium calibres is now reduced to a mere citadel, and the whole question of armour has therefore completely changed since the days of "La Gloire" and

[1] [*Note.*—The day for reading this paper was fixed by the Council, with the concurrence of Captain Zalinski, and the arrangement could not afterwards be altered. —GEORGE ERSKINE, *General, Chairman of Council.*

See also the remarks made during the discussion by Admiral Boys, Vice-Chairman of Council.]

the "Warrior." The mere momentary supremacy of the armoured protection of the over-water hull led to greater activity in the development of the submarine torpedo attack. This having been brought to a point where it has necessitated consideration, the under-water hull has been strengthened somewhat, and cellular subdivision renders the relatively small charges used heretofore in movable submarine torpedoes ineffective. Now, however, we are presented with the pneumatic torpedo-gun, which is capable of accurately throwing very large charges of high explosives to greater distances than those attainable by movable torpedoes. Again, it becomes a question whether the under-water hull, as it is made to-day, is not overmatched. Perforation of the over-water hull by ordinary projectiles is likely to produce only local injury. The perforation or the crushing-in of the under-water hull is more certain to be fatal, the more heavily the ship is weighted with armour. As to shock effect on machinery and propeller shafts at distances beyond the crushing-in radii, we have little experience; but there appears to be every reason to believe that a great source of danger to the ship lies in this new method of attack. Consideration of this indicates that the new weapon must become an important factor in the design and equipment of defensive structures and, hardly in a less degree, in those intended for aggressive action.

Time will not admit of giving all of the details of the system nor all of the steps in its evolution. I am provided with lantern slides and diagrams with which I shall be pleased to exhibit such details as you may desire to know more of.

A brief history of the inception and evolution may not be uninteresting in connection with a description of the system. Whilst I have been honoured by having the invention of the gun ascribed to myself, the person to first propose using compressed air for the propulsion of high explosives was Mr. Mefford of Ohio, and he put it into the first materialized shape in the construction of the 2″ gun in 1883. My attention was turned to it in the winter of 1883–84, and I was asked to express an opinion regarding it. I unhesitatingly replied that I did not think it practicable to throw very large charges of high explosives considerable distances with compressed air. Being assured that the 2″ gun had thrown a projectile to a range of 1 mile, I consented to test it, with the concurrence and assistance of my Commanding Officer, Colonel John Hamilton, 5th United States Artillery, now retired. Without this assistance the pneumatic gun would hardly have been developed as a practicable military machine. Mr. Mefford's ideas were as crude in character as was the machine which he presented. As a subaltern, I could not have carried on the experiments at a military post, and it would have been difficult to have carried them on elsewhere. Our own authorities with whom rest the selection and adoption of war appliances were too sceptical regarding this weapon to experiment with it. It is thus largely to the broadness of character of Colonel Hamilton that the pneumatic gun, as it is to-day, became possible. My own initial scepticism regarding the use of compressed air as the propelling power enabled

me to receive the scepticisms of other military men regarding the pneumatic gun with less impatience—with more tolerance. Convinced that it was of special importance to the United States, no efforts were spared to push it to a definite successful conclusion.

Following the 2″ gun came consecutively in construction the 4″, 8″, and 15″ guns, views of which I will now present. At the present time ten 15″ guns are being constructed of the type shown in the views. You will observe that whilst the 15″ gun already constructed is trunnioned at the breech, those now building are trunnioned towards the centre, being thus nearly balanced. One of these last-mentioned guns is for the Victorian Government, and is to be tested at Shoeburyness; the others are for the United States Government. The general characteristics of these guns and their accessories are as follows:—

The Gun.

The gun-barrel consists of a very light tube, at present a smooth-bore. As the firing pressure used does not exceed 1,000 lbs. per square inch it need not be more than half-an-inch thick, even in calibres as great as 20 inches, if made of steel or aluminium bronze. A greater thickness has been used in the 8″ and 15″ guns, for the purpose of obtaining somewhat greater rigidity and to lessen the chances of mechanical injury in transportation and manipulation. Where it is important to eliminate weight, as on shipboard or torpedo-boats, these tubes can be made very light, especially in cases where they are placed at a fixed angle. When the machine is to be movable for elevation or direction, or both, the barrel is supported on a suitable truss, and this in turn is supported on a gun-carriage similar to those used for sea-coast powder guns. The breech mechanism is a simple gate arranged so that the valve mechanism cannot function until the breech is closed and latched.

The Valve.

The valve is known as a "balanced valve," so arranged as to open and close by a single movement of the operator. The *time* of opening and closing can be varied by an adjusting device so that any desired loss of pressure will ensue. In this way the range can be changed without change either of elevation or pressure. The valve setting can be constantly changed to conform to the variations of range much more quickly and accurately than can be accomplished by corresponding change of elevation of a gun. The pressure in the reservoir is reduced at each fire by any predetermined amount, the valve being adjustable to accomplish this automatically. The most economical results are obtained with the air acting expansively. A loss of 12 to 15 per cent. with a reservoir of five capacities of the gun-bore is ordinarily the maximum which can be used with advantage.

The Reservoirs.

The air reservoirs used thus far consist of wrought-iron lap-welded tubes of $12\frac{3}{4}$ inches and 16 inches outside diameter and from $\frac{1}{2}$ to $\frac{13}{16}$ inch thick. These tubes are from 18 to 25 feet in length. The reservoir tubes from which the air for firing is directly drawn are known as the "firing reservoir." This reservoir will, as a rule, be of five capacities of the gun-bore. Reservoirs are now being made of steel ribbon tube, resulting in marked reduction of weight; the steel ribbon is wound spirally on a mandril, and the successive layers are wound in opposite directions, breaking joint and soldered together.

Where it is desired to fire a large number of rounds with great rapidity, an auxiliary storage reservoir is used, into which the air is compressed ordinarily to twice the pressure to be used in the gun. Thus the gun can be fired as rapidly as the shell can be inserted, and the piece properly pointed, for the number of rounds for which storage reservoir capacity is provided.

The Compressors.

The air compressors may be of any type capable of giving the required pressures. We have used the compressors of the Norwalk Iron Company. These compressors perform the compression in two and three stages, there being intermediate cooling in passing from the first compression to the last.

The Shell.

Two general classes of shell are used, viz., full calibre and sub-calibres. The full calibre shell is retained in its proper trajectory by a tubular tail piece having affixed thereon spiral steel vanes. These vanes serve to rotate the shell and keep it point foremost. The sub-calibre shell may be of any diameter smaller than the bore of the gun; they are kept centered in the bore by an attached gas-check of the full size of the bore, and by centering pieces attached to the body of the shell near the conical point. These are loosened from the body by the air pressure, when the gun is fired, and leave the projectile when clear of the muzzle. The projectile is retained in its trajectory by short spiral vanes, attached to the rear of the shell, of sufficient width to nearly touch the surface of the bore.

In this way, shell of 6″, 8″, 10″ and 15″ calibre carrying charges of 50, 100, 200, and 500 lbs. of explosive respectively, are fired from the 15″ gun. The smaller diameter of shell can, of course, be thrown a greater distance, as they weigh less and offer a smaller resistance in passing through the air, whilst they receive the same energy from the gun. Where it is desirable to throw any given charge a fixed maximum distance from a gun shorter than the normal length for the calibre, the same results may be obtained by making the gun of a larger diameter proportioned to the desired shortening of the gun barrel, and using sub-calibre shell. This will be of value for use on

shipboard where the available space may be limited, and has the great additional advantage that very large charges may be thrown out of the same gun when coming to closer quarters. In all shell, the bodies are kept from metallic contact with the bore by non-metallic centering pins and bearings, to avoid danger of heating the charge on friction. It is important to retain the centre of gravity of the shell somewhat in front of the centre of figure. This renders it necessary to construct the shell of a greater weight than would otherwise be required. Except for this, the shell could be made of as light tubing of brass, iron, or steel, able to withstand the crushing stress due to the aggregate air pressure upon the gas-check, and the set-back of the charge.

The Fuze.

As this part of the system is somewhat novel, I will describe more fully the steps which led to its development.

The earlier experiments with the pneumatic gun demonstrated that the ordinary fuze arrangements were insufficient to obtain the best results with high explosives. Ordinary percussion fuzes of fulminate of mercury were used at first, being placed in the point of the conical head. These fuzes did not act uniformly, and some failed to explode the charge. Further experiment with copper capsules of fulminate demonstrated that whilst some would explode upon very slight percussion, others would be entirely upset and deformed without resulting in explosion. This occurred with the most sensitive ones obtainable. Another noticeable fact was that shell charged with 17 lbs. of dynamite, having the percussion capsule in the front, upon striking and exploding on the shores of Fort Hamilton, sometimes failed to produce any marked effects. This result was very unexpected, but, upon consideration, it was assumed to be due to the initial point of the explosion having been in front.

It was assumed that as *time* was required for explosion of the entire charge—the gases evolved by the explosion of the layers in immediate contact with the target tended to throw *back* the gases afterwards evolved from the portions of the charge in rear. It therefore appeared desirable to make the initial point of explosion at the *rear* portion of the charge, and to prevent an explosion at the point from simple impact; that the explosion must be made to take place an instant *before* the body of the charge had actually struck the target. It furthermore appeared necessary to devise a fuze which, while not abnormally sensitive to explosion from shock when in the bore of the gun, would act upon the slightest touch when striking the target, and that its point of initial ignition could be placed at any desired point within the charge, or could be made to occur, simultaneously, at a number of points. In view of the unsatisfactory experience with ordinary percussion arrangements, it occurred to me to call to my aid the electric current, to enclose a small battery in the shell with suitable circuit arrangements and electrical primers.

The fuze problem presented great difficulties as the requirements appeared conflicting. These were:—1st. That in striking a rigid target, such as the side of a ship, the circuit should be closed an instant *before* full impact of the projectile; 2nd. Missing the ship and entering the water, that *explosion* should take place an instant *after* striking, so that the charge might be fully buried in the water and produce its maximum on the enemy, if within the effective danger radius; 3rd. Failing in this, to explode after reaching the bottom, and so that this last action may take place at will, without the other; 4th. To cause the circuits being certainly open until after the shell has left the bore of the gun. The problem presented for solution was found intricate and difficult. Very many practical difficulties had to be overcome. These have all been eliminated and the manifold and apparently diametrically opposite modes of action have been successfully obtained.

As soon as a suitable battery had been selected arrangements were made to try

experiments upon iron plates, to determine the best details of arrangement of the charge and of fuze. The following experiments were tried:—A target was constructed of iron plates. The plates were supported against the interior parade wall, and the gun was placed outside of the fort at the sally-port sixty yards from the target.

A blank shell charged with sand, total weight 30 lbs., was fired. It penetrated three plates, aggregating 2·5 inches. A similar shell, charged with dynamite, having no fuze, intended to explode on impact, penetrated only a single plate, and its effect was actually *less* than the blank shot previously fired. Another shell fired with a detonating fuze in the front of the charge did little more damage. An electrical fuze was then arranged so that the circuit should be closed just before the body of the shell came in contact with the target. The primer was placed in the rear part of the charge. To further ensure against premature explosion by simple impact, a layer of cotton waste was placed in the front of the shell. The resulting explosion was the most effective produced: the six plates of the target, aggregating 4·5 inches, being broken through and indented over a nearly circular area of about 18 inches diameter. The stone wall in the rear was also somewhat broken by the shock.

It was evident, from the results obtained, that the effects to be produced by the explosion of the dynamite shell would not be limited to simple puncturing of a target, but that it would produce cracks and breaks at points distant from the point of impact. This was shown in some experiments upon a stern-post of the steamship "Nankin," forging about 5 inches by 8 inches in cross section; charges of 3 lbs. were exploded upon it. They simply dented the piece at the point of placement, but broke pieces of 2 feet in length at the extremities 6 feet and 8 feet distant, and produced large cracks at other points.

The electrical fuze consists of four parts, viz., the electrical battery, the circuit-breaker, the low-tension igniter, and the detonating cap. If delay action is required, a slow-burning train is inserted between the igniter and the detonating cap.

The chloride of silver battery has been selected as being most suitable. Although the electromotive force is low, the internal resistance of the battery, as made, is very low, and a single element suffices to bring the bridge to a red heat. To provide against accidental increase of resistance in the circuits, and to reduce the *time* required to fire the primer, one set of batteries is made quadruple, the other two sets are double. Each set is arranged in series. All of the elements of the quadruple battery are wet with salt water or sal ammoniac before insertion into the shell. One pole of this battery is connected, through the primer embedded in the fulminate of mercury detonator, to the metallic body of the shell; the other pole is connected with a light copper cone fixed in the conical point of the shell, and insulated therefrom. The shell striking any solid target, either normally or otherwise, will cause the outer shell to crush in on the insulated cone, close the wet battery circuit, and explode the charge.

A double dry battery is placed in the point and at the rear end. This last is inserted as a matter of precaution rather than absolute necessity. One element of each of these double dry batteries is wet up, and is ready for action as soon as the salt water enters the other element. Upon the shell entering the water the dry element becomes wet: the current then passes through a primer, which ignites the detonator. The time train is adjustable so that a variable submersion before explosion can be obtained. The rear dry battery acts in the

same manner should the other fail. If it is desired to cause the shell to reach the bottom before exploding, a water cap is attached to the dry battery in point of the shell. Provision is made to protect the front and rear batteries from moisture until the shell has left the bore of the gun. A spring valve is placed over the front dry battery to keep out accidental moisture. This spring is made rather stiff, as it is found that the impact with water is sufficient to open it, and it was desirable to provide for the contingency of the gun barrels on shipboard being filled by the waves with water. But if filled when the shell is fired, these valves would open and admit water to the battery and make it active. The shell would then explode shortly after leaving the muzzle. As this is not desirable, an independent circuit-breaking device is introduced, which causes the circuit to close only after striking the water.

For countermining and for action against earthworks, the collapsible head is omitted, and a delay action time train may be inserted. For action against earthworks, a wet battery is substituted for the dry battery in the point or base. The circuit-breaking device ensures all circuits being retained open until the shell has left the bore of the gun. If anything should be amiss with the circuits, no explosion will result until the shell is some distance beyond the muzzle. This, however, is impossible if proper care is taken in making up the shell, arranging the circuits, and testing. The circuits can be tested at any time before inserting either the batteries, primers, or detonators. The batteries, primers, and detonators need not be inserted until just before using. A double set of circuit-breakers, primers, and detonators are used to increase certainty of action.

To guard against the chances of breaking the very fine filament of platinum wire constituting the bridge, it is embedded in a cake of compressed gunpowder or other solid material with suitable priming around it.

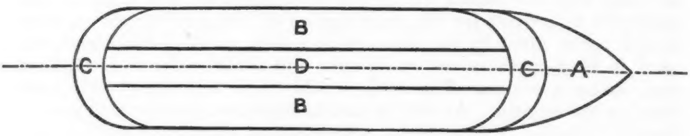
The Charge.

The charge used thus far has been uncamphorated explosive gelatine, having a core of dynamite. This core is for the purpose of producing a complete detonation of the less sensitive explosive gelatine. I would have preferred for this purpose compressed dry gun-cotton, as cold weather does not affect its properties as a detonating substance. With dynamite also there is great danger of exudation of the nitroglycerine when the charge remains in a fixed position for any length of time. The liquid explosive gravitates to the lower side of the charge and finally exudes. This of course is extremely dangerous.

The arrangement of the charge is essentially as shown in the diagram. At the front and rear of the charge I would use camphorated gelatine to increase the chances against explosion by shock, both in starting the shell and in striking the target. For this latter purpose also a diaphragm is placed so as to stop off the charge some distance from the point. This will give time for detonation of the

charge at the *rear end* before the front can be exploded by shock. I have preferred the uncamphorated explosive gelatine because it gives the maximum explosive energy for a specified volume of shell, both on account of its very great energy and its high specific gravity.

DIAGRAM OF ARRANGEMENT OF CHARGE.



A = Empty space at point.
BB = Uncamphorated gelatine.
CC = Camphorated „
D = Gun-cotton.

The energy compared to dynamite No. 1 is as 142 to 100, according to General Abbot and other authorities. Its specific gravity is 1·6 compared to 1·2 of dynamite Nos. 1 and 10 of gun-cotton. Thus, in a given volume of shell the explosive energy, where uncamphorated explosive gelatine is used, will be as 189 is to 100, when compared with the same volume of dynamite; compared with *dry* gun-cotton, it would be 263·100 or close on to two and five-eighths time the explosive energy. If *wet* gun-cotton is to be used there is a strong probability of the relative strength being greater. I am aware that there is some question as to relative strength of gun-cotton as given by General Abbot, and it is possible that the gun-cotton may be made denser, but it is seen that a large margin must remain in favour of the explosive gelatine.

It will rest with each Service to select that explosive which seems to it safest and best. I mention my own reasons for having selected and used uncamphorated explosive gelatine. I have used this for more than three years. It was made at the Nobel Explosive Company's Works near Glasgow. I have fired two tons of this. Besides use in the gun, I have subjected it to various tests of alternations of heat and cold, as well as subjecting it to very severe shock. I am satisfied from this experience that, if well made, and stored in a dark magazine of equable temperature not exceeding a maximum of 80°, it is not subject to deterioration whilst in store, or to explosion by shock if handled as carefully as gunpowder. The only thing unfavourable that I have observed, and that rarely, is a very minute exudation of nitroglycerine after freezing and again thawing. I propose to meet this contingency by having the cartridges made up in discs having a central hole for the detonating disc of gun-cotton. These large discs are to be covered completely by a rather thick covering of asbestos paper or other absorbent material having incorporated therewith an alkaline substance, such as carbonate of magnesia, or any exudations of nitroglycerine will be absorbed by the covering; any free acid which might be present or develop in the exuded nitroglycerine will be neutralized. Besides this, the thick non-conducting envelope will partially protect the explosive from great alternations of heat and cold.

Effect of Explosion of Torpedo Shell.—The torpedo shell has a double field of action, the over-water hull and the under-water hull.

There are very few if any complete experiments which show what large charges of high explosives will effect, either against the armour or the general over-water structure of a ship. The elements of suitable tamping and proper method of explosion have been omitted. The Scandinavian experiments quoted by General Abbot give us an approximate formula: $W = 3{\cdot}3d^2$ where W = weight of dynamite

No. 1, d = thickness of wrought-iron armour. This will give a perforation or rather breaking through, where uncamphorated explosive gelatine is used (taking this at 142 as compared to dynamite No. 1 at 100) as follows :—

55 lbs.	4·8 inches.
100 „	6·6 „
200 „	9·3 „
400 „	13·2 „
500 „	14·7 „
600 „	16·0 „
700 „	17·4 „
1,000 „	20·4 „

Experiments indicate that the decks of the most heavily armoured ships will probably be vulnerable to the 8″ torpedo shell charged with 100 lbs. of explosive gelatine, and even the smaller shell will break through. The torpedo shell charged with 500 lbs. will break through a very large proportion of the more heavily armoured parts. The decks and lightly armoured parts present a much larger proportion of the over-water target than the parts carrying more than 14 inches. When exploding against the more heavily armoured parts and failing to perforate, much damage will probably be incurred by the very great transmitted shock. This will seek out the weaker parts, and produce fractures at points some distance from the point of impact and explosion. It will also break up the hydraulic and steam mechanisms upon which the life of the ship now depends, and will place the personnel *hors de combat*. Where the explosive energy is greater than the resistance offered by the target, the result is something greater than a mere perforation. There is a general breaking in of the surrounding parts of the structure.

Should it be considered advisable to make the over-water hull, in its heaviest armoured parts, the objective point of attack for these torpedo shell, pneumatic tubes can be built to throw any charge requisite for breaking through, even if experiments demonstrate that a shell containing one ton was required to perform the work. But the work of attacking the over-water hull will be left to the high-power powder guns. I have only endeavoured to show that the torpedo shell is likely to produce much injury to the over-water hull, should it miss the real objective point, the under-water hull.

Regarding the effect of the explosions, when occurring under water there appears to be less question, except as to the size of the charge. Up to recently, less than 100 lbs. of gun-cotton have been considered sufficient. A natural sequence of the general use of auto-mobile torpedoes, such as the Whitehead, has been the strengthening of the under-water hull, at the same time increasing the cellular subdivision. This renders large charges desirable. The pneumatic torpedo gun system makes this perfectly feasible. It is simply necessary to establish the size of the charge to be thrown.

According to General Abbot, the explosion of 100 lbs. of explosive gelatine under water would be effective against a first-class war-vessel at the distance of 21 feet. More recent experiments indicate that this distance is too great. Lieut.-Col. J. T. Bucknill, late R.E., in a series of articles published in "Engineering," takes the danger radius of the same charge as being about 10 feet. This difference is partially due to the great strengthening and subdivision of the hull made necessary by the development of the auto-mobile torpedo. Whilst General Abbot assumes a pressure of 6,500 lbs. per square inch as fatal, Col. Bucknill assumes it at nearly twice this as being requisite.

The effective horizontal range of a 100 lb. charge would be at least 15 feet, whilst a 500 lb. charge would probably be about 50 feet.

If the explosion takes place at a somewhat greater distance than this, although the result would not be fatal, there is very great chance of the steering gear, shafts, and propellers being seriously injured and the vessel being rendered helpless to continue manœuvring, which is perhaps the condition to which one would most wish to reduce one's enemy. A shell striking, say, 100 feet from the target is likely to be within effective danger radius at the time when the explosion takes place, owing to the delayed action of the fuze.

Accuracy of Fire.

The question as to whether the pneumatic torpedo-gun can deliver accurate fire appears to be settled by the trial before the Naval Board in June, 1886, and the destruction of the "Silliman" on September 20th, 1887, as also in the test of January 26th, 1889. In the first case four out of five shell landed in essentially the same spot at a range of 1,613 yards—the other shell went about 7 yards beyond.

The lateral dispersion was slight. The destruction of the "Silliman," on September 20th, 1887, will be described later on.

On September 30th, ten shell were fired for rapidity and grouping. I was requested not to make any allowance for the variable conditions of wind. The gun was set at zero, although the wind was variable both in direction and force, and I could have changed the direction of the gun whilst loading, without loss of time. The men I had could not be called trained men. Ten shell were fired in 10 minutes and 45 seconds. Had the "Silliman" been anchored, end on, the bow or stern being at the buoy taken as a target, two of these shell would have struck the vessel directly, and four have exploded near enough to have destroyed the ship. Two others would have injured her seriously by the explosion.[1]

In the trial of the 15″ gun before the U.S. Naval Board, of which Commander Goodrich was President, the contract requirement of landing 50 per cent. of shell fired in a rectangle 150 feet long by 50 feet wide, at a distance of 1 mile, was exceeded.

The following extract from the report of the Board is pertinent:—

"The method of graphic analysis employed to ascertain the effect produced by the groups of shell fired at the three principal ranges shows that a moderate sized ship, broadside on, whose centre was anywhere between the limits of 1,988 yards and 2,218 yards, would have been struck by from one to five projectiles, either above or below the water-line. If end on, her centre being from 1,946 yards to 2,248 yards removed from the gun, she would have received from one to seven of the nine shots fired. Again, were the ship an average iron-clad, 333 feet long, with corresponding draught of water, &c., she

[1] A British Commission witnessed both the "Silliman" experiment and the rapidity test of September 30th, 1887. Indeed, the last mentioned was made at its request.

would have received all of the nine shots, either above or below the water-line, when 2,097 yards distant.

"There is, however, another effect which ought not to be neglected, viz., the torpedo action of a suitably fuzed shell passing under the ship. As the lateral errors are insignificant throughout the various series, it is fair to assume that the chances of inflicting damage on a vessel, either way placed, are thereby materially increased. Since the 'Silliman' was destroyed in this manner such a supposition is logically admissible. Granting that it adds only one more chance to each phase, and we see that of the nine shots fired at 2,100 yards eight would have been effective against a 300-foot ship, end on, and distant from 2,015 yards to 2,126 yards.

"At the 1,700 yards range a similar ship, broadside on, would have been struck by from one to three projectiles, according as her centre passed over the space between 1,625 yards and1,745 yards. On the other hand, if end on, she would have received an equal number when changing her distance between 1,574 and 1,786 yards; and the number of injuries received might be increased from one to two or from two to three within the same limits through torpedo action.

"At 300 yards range, a ship broadside on would have received from one to three shots between the limits of distance of 329 yards to 451 yards. End on, she would have received from one to two or from two to three shots between the limits of 298 yards and 482 yards.

"It appears finally, then, that projectiles either carrying or capable of carrying 200 lbs. of high explosive were thrown to distances varying from $1\frac{1}{4}$ miles to 90 yards, and that, at the ranges selected for grouping, viz., 2,100 yards, 1,700 yards, and 360 yards, not less than one-half of the projectiles fired fell in the same standard target with the trial shot."

"Silliman" Experiments.

Hon. Wm. Whitney, Secretary of the Navy, having asked the Pneumatic Gun Company what it was claimed that the 8″ gun at Fort Lafayette could do at 1 mile range, the answer was given that it could destroy any ship then existing in the United States Navy—that if any stronger ships were constructed, the Company would guarantee to build guns capable of destroying them. One of the ironclad "Monitors" was asked for as a target, should a trial be determined upon.

As the trial must necessarily take place in New York Harbour, the question of the expense involved in removing the hulk, should it be sunk, caused the substitution of a condemned schooner, the "Silliman," as a target. This vessel was only 80 feet in length, and 22 feet beam. At the range selected, 1,864 yards, anchored with her masts in the line of fire, she presented to the gunner a very small target. Being without ballast, her destruction was more difficult than if of larger and stronger construction. Experiments made at Newport with a similar unballasted vessel placed over a gun-cotton mine resulted in but slight injury to the target when the explosion took place. Empty sealed water-tanks were placed between decks to aid in floating the vessel if struck, and chains were placed around the ship to facilitate removal. Her complete destruction was not expected.

After firing one sand shell and one blind shell, a shell was exploded in the water some yards from the ship, resulting in shaking out the mainmast. A second shell exploded directly under the ship, amidship, breaking its back, and destroying it completely. This was followed up by a third shell which struck the *débris* above water and exploded in the air, whilst a fourth shell was exploded in the water near the wreck. The first shell was purposely exploded some

distance from the ship, whilst the last two were only fired to show the full control of the range, and the power of reproducing results time after time. The programme of firing one shell near enough to shake the vessel up without destroying, the next to be exploded under the keel amidship breaking her back, and, finally, one on top, above water, was laid out by myself some weeks before, on being asked what I intended to do. But the announcement, when made, was received incredulously. I based my assertion on experience with the gun, and its ability to reproduce results where the shell was well made, and this last was the only proviso I put to the above statement.

The accuracy of fire follows from using an uniform air pressure which can be absolutely gauged to within a few pounds, instead of varying several thousand pounds, as may be the case with the gun using powder. With the same amount of energy imparted to the projectile, if the latter is well and uniformly made, and is well balanced, it must necessarily attain the same range. Unlike the ordinary round, smooth-bore projectile, it cannot ballot, as it fits the bore in at least three circumferential lines, distributed along its length. It must, therefore, leave the gun in the direction of the axis of the bore.

Before proceeding to the question of the various uses of the pneumatic torpedo-gun system, I will discuss two points which are frequently suggested.

Rifling.

To the professional mind, it naturally occurs that it would be well to resort to rifling, dispensing with the long and cumbersome tail. To rifle a projectile so long, and so low in density as the one in use, would involve an exceedingly rapid twist. According to Professor Greenhill's formula, a twist of one in thirteen is required for a cast-iron shell eight calibres in length. This will be about the average length of the dynamite shell without the tail, being, however, somewhat shorter in the larger calibre. The density of the charged shell will be much less than of the common iron shell. Hence it is probable that a twist of about one in eleven will be required. To impart so sharp a twist will put a very considerable torsional strain on the thin walls of the shell, as also on the (proportionately) equally thin walls of the gun. Again, the explosive will have to sustain an additional shock, due to the very high angular velocity imparted to the shell. There is very great danger from the heat which will be generated in the friction of the projectiles, whilst being forced through the gun bore.

Whilst, as an artillerist, my natural predilections were for rifling, consideration of the foregoing facts led me to make haste slowly in this direction. I had constantly before me the experience gained at the Proving Ground at Sandy Hook and in foreign services, where the not infrequent results of the experiments of firing the high explosives from rifled powder guns was a final dissolution of the gun.

Use of Gunpowder for Propulsion.

The feasibility of using gunpowder for the propulsion of shell charged with high explosives is continually broached. It has been frequently tried but *invariably with final disastrous results*, where the experiments have been carried up to moderately large charges. By *large* charges, I refer to shell charges, where the percentage of the charge to the total weight is not less than 33 per cent., so that charges of from 50 to 1,000 lbs. can be thrown, and, if requisite, even 1 ton.

The advocates, or rather the predictors of the use of high explosives from powder guns, also demand penetration before explosion.

If large charges are to be thrown, the shell must necessarily be made thinner, and it is very doubtful if it will then withstand the concentrated blow it receives upon striking the target, so as to penetrate even a moderate thickness of armour. The battering shell of the 100-ton gun contains a bursting charge of only 32 lbs. of gunpowder. It would seem that the walls of the shell would have been made as thin as consistent with ability to perforate armour, without breaking up. Assuming that 32 lbs. of a high explosive could be substituted for the gunpowder, it is very doubtful if it could be carried through heavy armour successfully before explosion. There is no record of large battering shell fully charged with gunpowder having perforated armour over 6 inches in thickness, without explosion until after perforation. On the contrary, explosion takes place prematurely, almost immediately upon impact, with the result of less injury to the target than that produced by an uncharged shell. Much more surely will this be the case, if a high explosive be substituted for the gunpowder as the bursting charge, unless the shell cavity is well cushioned. To do this involves reduction of explosive capacity. The energy available, after breaking up the very thick and tough walls of steel shell, will be but little greater than that produced by gunpowder. The effect as to material injury or man-killing power will not much exceed that producible by the shell charged with gunpowder.

In firing a shell from a powder gun the walls of the shell must necessarily be sufficiently strong to withstand the initial shock. This limits somewhat the capacity for bursting charge, even where armour-piercing is not sought for. If a high explosive is used, some cushioning device is requisite, and a further reduction of capacity ensues. Assuming that a shell charged with some of the high explosives can be thrown with safety from a powder gun under normal conditions of pressure, it is known that abnormal pressures, varying therefrom as much as from 5,000 to 12,000 lbs. per square inch, are not infrequent. This may be looked for, especially when the gun is warmed by continuous firing, and the projecting charge of gunpowder becomes quickly heated. In this condition, its dissolution must necessarily be more rapid, giving greater initial pressures. In addition to this the shell and the contained charge may become warmed by remaining in the hot gun-bore some little time before being fired. The high explosives increase very rapidly in sensitiveness by

slight increments of heat. If then, with this condition of increased sensitiveness, we have in addition an abnormal pressure, a premature explosion is very likely to occur. In rapid firing of powder-guns, when shell or shrapnel charged with powder are used, premature explosions of the shell are not infrequent. Much more will this be the case when the bursting charge is one of the high explosives.

In this connection another matter is to be considered. It is well known that high explosives are capable of producing more or less violent explosions depending upon the character of the initial shock of detonation. The more insensitive the explosive, the more powerful must be the detonating charge to produce an explosion of the first order. Fulminate of mercury appears to be requisite in all cases, but fulminate of mercury is even more sensitive to shock than either ordinary dynamite or dry gun-cotton; hence the resulting shock must be tempered so as not to explode the more *sensitive detonating* charge rather than the specially insensitive *bursting* charge. Wet gun-cotton has been substituted for powder charges, but being quite wet reduces its explosive ability very considerably. Particularly is this the case where no detonating charge is used of dry gun-cotton and fulminate of mercury, or where this detonating charge is relatively small. Where the explosion takes place by simple impact, not alone is it of a low order, but, as the initial point of explosion is from the front, the resulting injury to the target is less than from a blank shell.

It is, therefore, almost useless to throw high explosives in powder-gun shell, unless at the same time effective explosions of a high order can be assured. This was exemplified in some experiments made at the Naval Proving Ground by Commander Folger, U.S. Navy, and appears to be corroborated by such reports of French experiments and the "Resistance" experiments as were attainable.

Where very large charges are to be used, the electrical primer enables us not alone to have rear ignition, but also to have a number of centres of simultaneous ignition, should this be found necessary.

From experiments made by Commander Folger, he arrived at the following conclusions, in some respects similar to those above stated. These are as follows:—

(*a*.) Using a weak shell charged with the high explosives, no material injury would result to the over-water defence of a modern ironclad, even with gunpowder as the propulsive force, and using greatly increased bursting charges. The effects *nil* with low velocities, will be equally valueless with high velocities.

(*b*.) It is believed that, using a strong walled *steel* projectile, the explosion occurring at impact at an elevation of temperature of less than 300° F., the effects will be less notable than with similar projectiles charged with gunpowder.

This last conclusion has been fully confirmed by experiments at Sandy Hook and elsewhere.

The use of gunpowder and the hydrocarbons in combination with the compressed air has been suggested. Both of these have been tried at Fort Lafayette, but with unsatisfactory results. It is difficult to eliminate both the elements of shock and heat to such an extent as to ensure safety beyond question, as well as that uniformity of action required to give the great accuracy of fire which has been obtained with the compressed air alone. The only explosion in a gun which we have experienced at Fort Lafayette was due to an experiment tried in Mr. Mefford's behalf. Having proposed a combination of powder and compressed air propulsion, he was permitted to

try it, with his original 2-inch gun, out of consideration of the fact of his having been the pioneer in this field. As I could not be present at the experiment, I gave directions to my assistants not to permit anyone to be exposed during the trial. The gun was burst as I expected. Mr. Mefford afterwards tried the experiment with a very complete system of air and other cushioning, at Sandy Hook, but with the same results—the bursting of the gun.

In my experimental work, whenever any new method or arrangement suggested itself or was suggested by others, the first question considered was as to safety. If apparently safe, tentative experiments were tried, which as far as possible would represent the conditions in the gun when fired. Safety being assured, here the experiment was tried in the gun itself. Quite satisfied with the degree of danger involved, even by the use of compressed air, and having as yet by its use accomplished much more in projecting torpedoes than has been accomplished by others, I am quite content to let the matter rest at this point until others have actually accomplished more by using gunpowder or hydrocarbons, leaving them to bear the brunt of the danger in trying to accomplish it. It is usually a very long and devious road from the conception of an idea to materializing it into a practical form.

It will be evident from the preceding remarks that the pneumatic gun is chiefly considered with reference to its ability to destroy ships. For this purpose it can be used both ashore and afloat. In discussing its various uses it is necessary to make comparisons with weapons already in general use in order to have its peculiar advantages recognized. Superhuman certainty of action and omnipotence are not claimed for it. The physical conditions involved, however, ensure unusual chances of obtaining success. But the judgment, skill, and nerve of the human operator are as essential factors with this weapon as with all others. It is not intended to imply that these last do not still have important fields of action. But the pneumatic torpedo-gun will certainly powerfully supplement them, and in some places be substituted for them.

For Coast Defence.

On land, these machines may be considered as valuable adjuncts to any system of stationary and movable submarine mines operated from shore, as well as to a portion of the high-angle firing armament which will be so largely used in modern defences. Their functions here are manifold. Let us grant for a time, entire sufficiency within their striking radii of the fixed mines when first planted, and that they have remained intact up to the time of action. In a very large harbour it is impracticable, from considerations of expense and physical conditions, to effectually cover the entire area of every avenue of approach by a suitable number of stationary mines. The guns should, therefore, be so placed as to effectually cover by their fire the mine-fields and all zones otherwise unguarded. In the course of action some groups of the fixed mines will be exploded either by the enemy's

countermines or by the defence, when partial advances are made by the enemy. It will be impracticable to replace these exploded mines in the face of an active enemy. The pneumatic guns will be able to cover by their torpedoes the avenues of approach thus otherwise left open, and shower the path of advance with their missiles.

The range of the gun—4,500 yards—is sufficient to throw its torpedoes far beyond the distance at which the lines of fixed torpedo defences will usually be placed from the main works, which must be able to protect them, or, at least, be able to delay the enemy in cases where countermining is possible. This range is also much greater than that of the dirigible torpedoes which some authorities appear to consider necessary adjuncts to a system of permanent defences. The controllable mine-fields are thus practically extended far beyond the range covered by the ordinary fixed and movable submarine mines.

Let us now examine some of the limitations of fixed and movable submarine torpedoes. The operation of putting down controllable fixed mines is one requiring a large, highly trained personnel, great care, and skill. It cannot be done hurriedly. Those who have had experience in this work will realize how many links of the chain there are which must be absolutely perfect to have the system efficient. The conditions of weather must be favourable. Storms may delay for a long period the putting down of a system of mines, at times when the delay may be fatal. To put them down long in advance of hostilities involves great chances of deterioration and injury by storms and other causes before they are needed. Where the channels are very deep, ground mines are not to be thought of, unless made exceedingly large. If the current is very strong and the rise and fall of the tide is very great, buoyant mines are hardly practicable, as it is not possible to have them within effective striking distance at all stages of the tide. It is true that buoyant mines and circuit-closing buoys have been devised to adjust themselves automatically to varying heights of tide, but these are complicated and not reliable. Judgment firing is not likely to be accurate and reliable, owing to the very large swing and variable position of the torpedo, and the limited effective radii, particularly of such charges as are considered practicable in buoyant mines. If mechanical mines are used, the channel is hermetically sealed to friends, but may be removed by an enemy quite easily by countermining operations to be described hereafter, as may indeed all of the others.

A group or system may be rendered useless, by cables being injured or cut, as well as by injury to the entrances of the operating casemates. If the system be a complete one, commercial channels would be blocked to an intolerable extent. A complete system is therefore only permissible, where, in case of war, the closing of the port to traffic is of little consequence to a belligerent Power.

As to the dirigible torpedoes we have, at present, only the Patrick, the Sims-Edison, and the Brennan torpedoes to consider. The Patrick torpedo has a speed of 20 miles, weighs about 5,000 lbs., carries a charge of 300 lbs., and costs about 15,000 dollars. The Sims electrical torpedo has a speed of 11 miles, weighs about

4,500 lbs., and carries a charge of 300 lbs.; it costs about 7,500 dollars. Of the Brennan torpedo little of detail is generally known, except that it, like the Sims and Patrick, must be connected with the operating station by wires. In all of these a very large life artery is exposed to injury. The speeds now claimed are 20 miles for the Patrick, 18 for the Sims, and 27 knots for the Brennan.

Two, if not all, of these three are expensive, and all are bulky and relatively of no great speed. They must be seen the entire distance to be operated. This is a matter of no little difficulty at distances exceeding one-half a mile, where there is any mist, smoke, or rough sea. On coasts like that of Great Britain, where mists and fogs are not infrequent, this is a matter of grave importance, particularly where the operator is but a short distance above sea level. If they can be seen by the operator for the distance of maximum range (supposed to be 1 mile for the Patrick, $1\frac{1}{2}$ miles for the Brennan, and 2 miles for the Sims torpedo), the chances are fair that the vessel to be attacked will discover the approach in time to evade the blow. It should be noted that the greatest speed claimed for this last-mentioned torpedo is less than that of the most recently constructed ships of war, the Brennan alone exceeding it. It is within the range of possibility to stop or deflect them from their target. On the other hand, the projectiles of the pneumatic guns may be effective without making absolute hits. Neither booms nor netting can stop them. They are not affected by waves and strong and variable tidal currents. Their mean horizontal velocity for a range of 2 miles is about 300 knots, as against the maximum velocity of 27 knots recently claimed for the Brennan and very much less of the others mentioned. The attainable range is much greater. It can be used in conditions of mist and fog and rough water which would be impracticable with the dirigible torpedoes, as the hull of an enemy's ship would be visible at times when it would be utterly impossible to see the small unsubmerged portions of these machines. The operating chambers and launching ways for the Brennan must necessarily be at the water's edge, and their position would be surely known to the enemy. They would surely direct their fire so as to injure these, whilst they could anticipate with certainty the points from which they could be attacked. On the other hand, the sunken emplacements for the pneumatic torpedo-guns can be removed from the shores without anything to indicate their position directly to the enemy.

Only a single Sims-Edison or Brennan torpedo can be manipulated from each operating dynamo or engine, and the number of these must be multiplied accordingly. It is not beyond the mark to say that the Brennan torpedo could not be made to complete a full run, and have substituted for it another torpedo and made a run, in less than six minutes. Within that time if the target is moving only at 12 knots per hour, it is not likely that it will be within range for a second shot from the same station. The pneumatic gun can deliver its fire at the rate of one round per minute, and more frequently if required; and a single gun could fire about fifteen rounds whilst a vessel is within its range, under conditions similar to those reported to have

existed in the recent Isle of Wight experiments. The relative cost of each torpedo is very much less, being from one-thirtieth to one-sixtieth in the case of the Sims and Patrick torpedoes respectively. Without an exact knowledge of the cost of the Brennan, and without considering the amounts expended for the right to use it and its development, I venture to say that each torpedo costs at least twenty times as much as the aërial torpedo shell carrying the same weight of explosive.

The following remarks made recently by Lieutenant-Colonel Walford (h. p.), R.A., before this Institution, appear to be well suited in considering the relative value of the pneumatic gun for harbour defence, when compared to fixed mines.

II. The defence of guns is active; that of mines passive.

III. The destruction of mines is a matter of time; the silencing or destruction of guns requires something more.

IV. Guns are always ready; mines require careful preparation, and constant care and renewal.

From this it would appear that the pneumatic gun will, in all places, form a valuable supporting adjunct to the fixed mines, where these are feasible, entirely replacing them when injured or removed. In very deep channels or where the currents are swift and the rise and fall of the tide considerable, and the commercial use great, the pneumatic torpedo-guns should be substituted entirely for the fixed mines.

As examples of situations where the pneumatic torpedo-gun appears to be peculiarly suited for the torpedo defence of the Channel, we may cite the Mersey at Liverpool, and the Golden Gate at San Francisco, in the United States. At Liverpool we have, in the Mersey, a channel having a rise and fall of tide of from 23 to 33 feet. The current being strong, and the passage incessantly used for commerce, buoyant mines are inadmissible, even if the difference of depth at high and low tide did not affect unfavourably the striking distance of the torpedo, and rendered the position too uncertain for judgment firing. The distances to the channel from any position on shore where the operator could be placed are so great as to make it difficult to successfully operate the controllable fixed mines, and entirely out of question to operate therefrom successfully the Brennan torpedo. A few pneumatic torpedo-guns placed here could cover a large area of the channel, be always ready for action without blockading the channel, and require but a small personnel to operate them. At San Francisco the channel is so deep and current so swift that both fixed and buoyant mines are inadmissible. Three 15-inch pneumatic guns have already been ordered by the United States Government for this position as well as seven others for New York Harbour and Boston.

Besides their use as an adjunct to or as a substitute for torpedo defences, these guns may also be considered as a portion of the armament for high-angle fire, with the advantages of greater accuracy than the howitzer, and the chances of producing decisive results even when missing direct hits. They will be particularly useful in protecting the interior zones, whilst the high-angle powder-gun armament protects the outer zones.

It is frequently argued that the range of the pneumatic gun is too short to be used effectively against an attacking fleet armed with long-range powder guns. Against this we bring the argument of actual experience in the bombardment of Alexandria and elsewhere. Here the British Fleet practically exhausted its supply of heavy ammunition; although the ranges averaged less than 3,000 yards, the works were so little damaged that they would have been defensible by good troops.

At the Inchkeith experiments from H.M.S. "Sultan" of August, 1884, with a calm sea and firing with extreme deliberation at a gun mounted *en barbette* at ranges varying from 850 yards to 3,500 yards, the injury produced in firing thirty rounds from the 10-inch R.M.L. was that only four dummies representing cannoneers were hit, and the gun-carriage so slightly injured that the gun could still be worked.

Further experiments at Inchkeith with machine and rapid-firing guns at ranges within 2,000 yards, produced no very appreciable results.

At the experiments at Portland bill, November, 1885, from H.M.S. "Hercules," at a disappearing 10-inch B.L. gun dummy, the ranges being only 750 to 950 yards, firing 6,910 rounds from 1-inch and rifle-calibre guns, and 29 rounds from 6-pr. Hotchkiss, there were only 16 direct and 9 splinter hits, notwithstanding that the disappearing device had broken, so that the dummy was exposed for three minutes continuously out of the ten minutes during which the firing lasted.

Again, at ranges from 2,200 to 2,845 yards 15 rounds of 10-inch common shell and 13 rounds 10-inch shrapnel were fired without any results.

A fleet will not, in view of these experiences, waste its limited supply of bulky and expensive ammunition at long range. It will surely close to range well within the field of action of the pneumatic torpedo-guns, and these will then be able to do effective work for the defence.

As the objective target of the pneumatic torpedo-gun is the under-water hull, and ricochets are very irregular, it is desirable to use such angle of elevation as to ensure the shell not ricocheting. For this reason, direct fire is undesirable and high-angle fire must be resorted to. Ordinarily an angle of not less than 18° should be used, as at lower angles the shell may ricochet. As a consequence of this, deep sunken emplacements, now considered the best for all guns, when possible, are well suited to these guns. At 18° elevation, as the minimum angle of fire, the muzzle of the gun may be 8 feet below the crest of the glacis, when the gun is horizontal. The boilers, compressors, and storage reservoirs can be placed well under cover, some distance removed from the guns, if considered desirable.

These guns are well adapted to land siege operations, as they can be transported in sections of comparatively light weight, and put up in the trenches. With suitable delay action fuzes, the torpedo shell could do most effective work against earthen parapets, whilst they would be extremely demoralizing if exploding within a work. Even if filled with the large charges of gunpowder which these shells can contain, very effective work would be done. As there is no smoke and but little noise when operating the pneumatic gun, if placed behind hills or woods, it will be very difficult for the enemy to locate the battery. Air compressors, worked by horse-power, have been designed for use in siege operations.

Naval Uses.

With the question of accuracy on land established, the naval Officer, bearing in mind the difficulties he meets with at sea in firing powder guns accurately, doubts the ability to obtain accuracy afloat with the high-angle fire of the pneumatic gun. We shall therefore have to examine this from the naval point of view. The unknown range and unstable platform enter as factors of uncertainty. The flat trajectory of the powder gun does not require such accurate knowledge of the range as in the case of the high-angle fire of the pneumatic gun. To this I would answer that the latter has practically a larger target presented, both in having the large area of deck available, and in the considerable danger zone surrounding the ship.

As pertinent to this, the following remarks by Ensign Brainard, U.S. Navy, may be interesting in this connection:—

Of foreign cruizers that might possibly attack our ports, most of them—about 97 per cent.—are armoured. Their average speed is 14 knots, length 305 feet, breadth 62 feet, depth 25 feet, height 26 feet. Taking this as the average attacking ship, we have as a target for a high-powered, low trajectory rifle, counting chance of ricochet, an average parallelogram of 52 feet in height, and 257 feet in breadth; as a target for Whitehead or similar auto-mobile torpedo, we have a parallelogram of 25 feet by 257 feet; as a target for the pneumatic gun, we have, taking 15 feet as the effective explosion distance, a parallelogram of over 66 feet by 287 feet. The areas of the parallelograms are for powder rifle, 13,364 square feet; for submarine torpedo, 6,425 square feet; and for pneumatic gun, 18,942 square feet. The pneumatic gun has, therefore, the largest target. From the data at our disposal, the average error at 1,000 yards, in train, is 18·8 feet for the pneumatic gun. This compares well with the rifle guns in use, and especially well with the smooth-bore shell guns to be found in the Navy. No such accuracy is even hoped for in auto-mobile torpedoes. Average time of flight of projectile from powder gun, 1,000 yards, 3·2 seconds; of auto-mobile torpedo, 143 seconds; of shell from pneumatic gun, 6·25 seconds. Taking into account the various directions or courses our enemy may steer, he will have an average motion across the line of fire of 16·57 feet per second. He will, therefore, move 53 feet while the rifle projectile is making the range; 2,369·5 feet while the torpedo is making it; and 103·6 feet while the shell from the pneumatic gun is travelling the distance. The rifle has the advantage here, the pneumatic gun coming next, and the torpedoes are way astern.

* * * * * * *

Ensign Brainard has given too small a danger radius for the aërial torpedo shell. If 200 lbs. charges are considered, the effective danger radius will be not less than 25 feet. This will add about 7,000 square feet to the area of the target for it, thus giving about twice the area allotted to the powder gun. Any increase of the parallelogram for the powder gun projectile, due to chances of ricochet is hardly warranted in view of the very erratic and very high trajectories of the latter after striking the water and ricocheting. They would then hardly strike the target unless the original line of fire was very wide of the mark. He allows also for a chance at the under-water hull. This is hardly attainable in view of the very great ease with which shell ricochet which are fired at low angles.

Summarizing this, it appears that we may claim for the pneumatic torpedo-gun at least twice the size of target presented for the powder gun, and four times that for the submarine movable torpedo.

It is conceded that the flatter trajectory of the high-power powder gun gives it some very important advantages as to increased danger space when the platform is perfectly stable. But there are also some disadvantages when used on shipboard, for errors of angles of elevation

due to rolling of ship may produce very marked changes as to point of impact on the vertical target, which is almost alone attainable by its fire at short ranges; the errors of range as to the horizontal plane will also be considerable. An error of angle of fire of only fifteen minutes, of the high-power powder gun, will throw its shell, at a range of 1 mile, about 23 feet above the point aimed at. The change in range will be, with the 8″ B.L. rifle, 230 yards. An error of angle of fire of 15 minutes with the 15″ gun of the dynamite gun cruizer will produce a change of 15 yards.

Not being a naval man, I must again cite the testimony of a naval expert. Referring to the chances of accuracy of the guns of the "Vesuvius," Commander F. M. Barber, U.S. Navy, states as follows:—

"The rolling of the boat will affect the accuracy of the two outer guns more than that of the middle one, but there should be no great difficulty in firing the gun by hand or automatically at the middle of the roll if it is not excessive, and if it is excessive no other gun would do better.

"The pitching of the boat is a more serious matter, as we all know that our principal errors at sea are in elevation and not in train . . . . it will be well to bear in mind that, although this boat is very sharp, it is not likely that she will ever be called upon to use her guns in any sea that would cause her to pitch excessively. According to M. Bertin, the proportion of the maximum of pitching to the maximum of rolling in most ships is only 1 to 5, and in the experiments with the 'Devastation,' 'Agincourt,' and 'Sultan,' it was found that for each *degree* of inclination, the bow of the 'Agincourt' would move vertically 4 feet, and the 'Sultan' 3 feet.

"The apparent angle was very great, but *actually* it was very small. In waves 400 feet to 650 feet long, and 20 feet to 26 feet high, the average pitch of the 'Devastation' was only 4°, and that of the 'Agincourt' was less. The length of the 'Devastation' is 285 feet, and the 'Agincourt' 400 feet. Now, the dynamite cruizer is 252 feet long, a very great length in proportion to that of any waves that she is likely to be used in, and her weights are not badly disposed. A change in the vertical height of the whole gun due to such waves would make but little difference in the trajectory, while with regard to the effect of the angular change, this gun has greatly the advantage over a gun with a flat trajectory. . . .

"A change of angle of elevation of 4° would vary the range only about 260 yards, or less than 2½ ships' lengths."

Probably the greatest difficulty which the naval gunner has to contend with is to ascertain the range of the target rapidly and continuously. To meet this difficulty, Lieutenant Bradley A. Fiske, U.S.N., has invented the electrical range-finder. Two instruments are placed on deck as far apart as practicable, and are continuously pointed at the target by two observers. No readings need be taken by the observers. The results are obtained by a third observer almost automatically and continuously at any part of the ship desired. In the case of the "Vesuvius," the range will be indicated on a dial in the gun-room, so that the valve settings may be continuously adjusted to the varying ranges. The gunner in the conning-tower will not, therefore, have to concern himself with the range, but will select the moment of operating the firing lever when the line is correct.

At a trial of Lieutenant Fiske's range-finder at night, with rather crude appliances and a very short base, results were obtained with an error of only 1·1 per cent., up to a distance of 2,600 yards. This degree of accuracy is sufficient for all

practical purposes, particularly in view of the size of a man-of-war. It is purposed to use another device by which the firing lever is kept automatically locked, except when the vessel is within any desired limit from its normal keel position as to pitch or roll. The gunner pulling the firing lever when the line appears to be correct will be prevented from moving until the angle is approximately correct. It is true that this may limit the number of fires available in a given time, but it is much better to fire less frequently, but with increased chances of attaining results. Should an automatic device fail to act, it is thought that the locking device might be operated by a gunner who will give his sole attention to the status of the ship with reference to its angle. In short it is proposed to give the gunner as little to think of as possible beyond pulling the firing lever, when the gun is directed on the target.

As to the alleged slowness of flight of the shell and the probable displacement of the target during the time of flight, considering it as a torpedo, it might not be amiss to further compare its velocity with the best auto-mobile submarine torpedoes, at present assumed to be the Whitehead. Granting to these last, for a range of 300 yards, a mean speed of 25 knots per hour, this would imply a velocity of about 42 feet per second. The mean horizontal velocity of a shell from the pneumatic gun at a range of 1 mile is about 580 feet, or about fourteen times as great as that of the movable submarine torpedoes. This certainly is not an unfavourable showing as to relative speed. The enemy's ship, therefore, will not have moved as far during the time of flight through a distance of 1 *mile* of the torpedo from the pneumatic gun as during the passage of the submarine torpedo through a distance of only 300 yards. Again, the latter must make an absolute hit, while the former may be effective even when having missed the target by a good many feet. Of course a skilful gunner will make allowance for the probable movement of the target during the time of flight, and accuracy of judgment in this case need not be so great as in the case of the submarine torpedo. Assuming that an enemy's ship 300 feet in length is moving at a speed of about 12 knots, it will have moved little more than one-half of its own length during the time of flight of the shell for a range of 1 mile; if the ordinary movable submarine torpedo is discharged at its effective range of only 300 yards the vessel will have moved more than once and one-half times its own length, or nearly three times as far. At greater speed of the target than 12 knots the disparity of distance will be even greater. Even conceding 33 knots as the speed of the Whitehead, the disparity is still very great.

When the pneumatic gun is brought to closer quarters than 1 mile, the chances in favour of its torpedo are relatively greater.

It is said that in the use of movable torpedoes exact knowledge of the range is not required. But unless used against a stationary target this is not the case; owing to its relatively slow speed, a close approximation of the enemy's range as well as speed of movement must be made, to make due allowance for the probable displacement of the target during the passage of the torpedo. If delivering fire against the broadside of a ship the submarine torpedo has as its margin one-half the length of the ship as to its direction, but with the chances of the results of errors of judgment being increased by its long time of flight. The torpedo shell has the same margin as to its *line* of fire, increased,

however, by some yards ahead and astern of the target and the very much shorter time of flight. In addition to this, the latter has, for this case, a margin for error of range of certainly twice the width of the ship, the margin being greater in both directions where larger charges are thrown.

If the fire is delivered ahead, the submarine torpedo has a margin of only one-half the width of the ship well *below the water-line*, where the breadth is less. The torpedo shell has practically a margin of the width of the ship as to its line of fire, owing to the danger zone when missing the direct hit. It has also a margin as to error of range of something more than the length of the ship. Besides this, a vessel carrying the pneumatic torpedo-gun can deliver fire directly ahead *whilst moving at full speed.* The torpedo-boat using the submarine torpedo *must either turn and expose its broadside, or slow up very considerably* before attempting to deliver its fire straight ahead, if it is to avoid danger of running into its own torpedo. I will continue the comparison of the torpedo shell of the pneumatic gun system with auto-mobile submarine torpedoes. The Whitehead torpedo, whilst having a possible range of 1,000 yards, can hardly be said to be very accurate even at 300 yards. Particularly is this the case when discharged from a vessel in motion, and very great fault has recently been found with this. It is subject in its flight to varying and unseen eddies, currents, and waves. It must make an absolute hit to produce results. It may be stopped by booms or netting. It carries so small a charge that even if in contact with the enemy's hull, doubts are expressed of its efficiency. It is relatively bulky and expensive, particularly the most recent large type. Very few can well be carried, and each time one is used a considerable proportion of this portion of the armament is thrown away.

Torpedo-boats.

The gun can be used advantageously on board of torpedo-boats in lieu of ordinary movable torpedoes or in conjunction therewith; some of the advantages, compared with the latter, have already been stated. To get in the shot at all effectively, if equipped only with the ordinary torpedo, they must approach so near that discovery is almost inevitable, and the chances of escaping the firing of machine and rapid firing guns are comparatively slight. The dangers to the torpedo-boat may well be deemed to be inversely as the square of the distance, and a boat which approaches to say 352 yards (one-fifth of a mile), will have one twenty-fifth of the chance to escape the enemy's fire, and to get in its own fire, possessed by a torpedo-boat carrying pneumatic guns capable of firing their aërial torpedo a distance of one mile.

The objection is raised that the long tube of the pneumatic gun will be difficult to manipulate accurately and quickly whilst in motion. Recent experiments have enabled us to produce the same results with much shorter barrels, more easily manipulated on shipboard. The "Vesuvius" guns have been shortened from a length

of 70 feet down to 55 feet. A 15-inch gun for land service has been built, which is only 32 calibres in length, whilst powder guns are made frequently 35 calibres in length, and will be made even longer.

Besides this, the peculiar character of the valve arrangement make it unnecessary to constantly change the elevation, although it is purposed to make this adjustable when required.

It is urged that the thin gun barrels will be easily injured by the enemy's fire of machine and rapid firing guns, that there is very great danger of exploding the shell whilst still in the muzzle. Torpedo-boats for the Whitehead torpedoes have over-water discharge tubes. These are even more liable to injury from the same kind of fire, and the torpedoes may be exploded before being ejected, as they must approach nearer to the enemy. It is difficult indeed to carry on operations of war without some danger to the combatants. The striking, by the enemy's fire, of the very much exposed over-water discharge tube of the Whitehead torpedo, before it is brought in action, will be quite as disastrous as the explosion of the aërial torpedo shell, at the instant that it is leaving the muzzle. The pneumatic torpedo tube may be so placed as to bring the greater part of its length below the deck. The breech section containing the shell is below the water line, and can be further protected by coal and armouring, such as protective decks, &c. Should it be considered desirable to use the gun at lower elevations, more protection might be afforded in heavier plating of the decks and semi-casemate or hood directly over the guns. The muzzle part which projects above the decks can be made very thick, and may be protected by movable hoods or shields. Thus, very fair protection can be given both to the tube and to the torpedo, except at the instant of firing. Recent experiments with rapid firing guns against heavy powder guns as high as 9·2″ in calibre, show that even these may be seriously injured, and rendered *hors de combat* by this species of missiles.

Although greater weight will be demanded for the pneumatic torpedo-gun than for the ordinary torpedo appliances, it is thought that the advantages of greater attainable range, greater charges thrown, and more accuracy, will compensate for this disadvantage. The small weight and bulk of the torpedo shell aid to balance the greater weight of the gun, &c. A larger number of torpedo shell can be carried. A revolver boat gun of 8-inch calibre has recently been designed, weighing with complete equipment not more than 8 tons. This is capable of firing eight shells in about two minutes. One of 10-inch calibre will weigh about 10 tons.

The loss of speed, due to carrying heavier weights, is compensated for the longer range of effective action than with the ordinary torpedo. But if we consider the combined speed of the vessel and its torpedo, a very wide margin is left for the pneumatic torpedo-gun vessel.

U.S. Dynamite Gun Cruizer "Vesuvius."

This vessel is equipped with three 15-inch guns, placed at a fixed angle of 18°, all parallel with the keel and abreast of each other,

pointing forward. The guns are directed by steering the vessel, the range being varied by changing the setting of the valve, which changes the "cut off," the pressure remaining the same. The vessel having twin screws, it has been found that the direction can be given very readily. Three calibres of shell will be used, 8″ and 10″ sub-calibres and 15″ full calibres. The ranges will be 2 miles, $1\frac{1}{2}$ miles, and 1,500 yards respectively. The rate of fire will be once per minute from each gun, and thus one shell can be thrown every twenty seconds. Thirty-three rounds can be so carried as to maintain the maximum rate of firing until these are expended. We can hardly imagine a condition of things where a larger number would be required, before decisive results are obtained one way or the other.

Comparison of the "Vesuvius" with the "Ilgin," "Tripoli," "Destructor," "Sharpshooter," "Rattlesnake," and "Bombe" show that she can launch more than three times as much explosive as is carried by the largest of these, to more than five times the effective range if we consider the largest charges, and this in about one-half time required, where seven torpedo tubes are to be used. If the comparison is extended to shell carrying the 200 lb. charges, the "Vesuvius" guns still maintain superiority of the amount of explosives thrown, and the range becomes close upon ten times as great as that attainable by the locomotive torpedoes. If comparison is made of a pneumatic torpedo-gun as mounted on the "Vesuvius" with a single torpedo tube, the rate of fire is as eighteen to one. With new designs for torpedo-boat guns, the rate will be five per minute or thirty times as rapid as that attainable by the Whitehead torpedo tube.

It hardly seems worth while to continue the comparison farther, as it must be obvious that the pneumatic torpedo-gun, as mounted in the "Vesuvius," can throw more explosive to far longer ranges, and with much greater rapidity than is possible with any other system now in existence.

The "Vesuvius," having a speed of more than 20 knots (she has attained 21·65 knots at the official trial), cannot but be a formidable vessel, with her armament. It is flippantly said that she will be easily and surely destroyed by the rapid gun fire; but this is not so obvious, as she need not necessarily choose broad daylight or perfectly clear weather to make her attack. She has the same choice of times and place to make her attacks as are open to the ordinary torpedo-boats, and being able to operate at so much longer ranges has a very much greater chance to produce results before she is destroyed.

Torpedo Rams.

It is perfectly possible to construct vessels of moderate size, of very low freeboard, of fair speed, quite heavily armoured, and of such form as to defy the rapid gun fire, and approach the most powerful war-ship afloat, with more than fair chances of sinking her, if equipped with large calibre pneumatic torpedo-guns. In fact, something approaching this description, called the harbour-defence vessel, is now building for the United States at San Francisco. This vessel

will carry, besides other armament, a 15″ revolver pneumatic torpedo-gun in the bow, capable of throwing five shells, each carrying 500 lbs. of explosive gelatine, in one minute.

A vessel such as the "Polyphemus," if equipped with one or more pneumatic torpedo-guns, would become very much more formidable than when equipped only with an armament which implies an approach to the enemy within 300 yards or to actual contact.

Use as an Adjunct to Ship's Ramming.

It is held by many naval Officers that ships will use the ram in the course of naval combats. Granting this, a modification of the pneumatic torpedo-gun of 15″ or 20″ calibre, throwing charges of from 500 to 1,000 lbs. of explosive gelatine, can be introduced into a ship, of such form as to be but very little in the way. In case of ramming being undertaken, it would serve as a most valuable adjunct, and might be said to be equivalent to extending the length of the ram from 800 to 1,000 yards. The chances of pointing the ship fairly at the enemy's broadside, at this range, are much better than of coming to an absolute contact.

This could be done by placing in the bow of the ship a tube about 30 feet in length and say from 15 to 20 inches in diameter. The gun may be placed parallel to the keel, and at a permament angle of elevation of say 20°. The tube may be fixed, the muzzle coming out at the bow somewhat above the water. The muzzle should, of course, be protected by a suitable movable shield. The body of the gun, especially that part in which the charge is placed, the breech, being well below the water-line, is sufficiently protected. The bow ordinarily is very little subject to being hit. A 20-inch shell could contain about 1,000 lbs. of gelatine equivalent to 1,420 lbs. of dynamite; with a pressure not exceeding 500 lbs. it could be sent at least 800 yards in advance of the ship, it being assumed that she is steering directly upon the enemy.

Should there be a direct hit of the enemy's hull above water, there can be no doubt that the detonation of this enormous mass of explosive would be extremely injurious; exploded below the water-line it would certainly be fatal. The additional weight demanded by adding such a tube to the armament would be small compared to the results attainable. The gun may be arranged as a revolver, so that five rounds may be fired within one minute.

I consider this one of the most important uses of the gun—being readily applicable to vessels now in service. Even if it were only possible to place a barrel 20 feet in length, excellent results would be obtained.

Countermining.

Besides the direct aggressive action against an enemy's ship, I would call special attention to the great utility of the gun for countermining. In no other way can this be done so thoroughly and readily, with the minimum danger to the besiegers. Operations may be commenced 2 miles from the nearest point at which the mines are likely to be placed, and continued with relative rapidity. Not alone will the aërial torpedoes be effective against the ground and floating mines

operated from shore stations, but the operating cables are likely to be cut, and entire groups rendered innocuous. Besides this, all mechanical mines will be destroyed within a very large radius of the countermining explosion. Shell with smaller charges can be used for this purpose.

A vessel carrying three 15″ guns has been designed especially for this work. It is to be of 3,300 tons displacement on a draught of 18 feet—to be turtle-backed, protected by 5 inches of steel armour, and to have its under-water hull made especially strong, being well protected from the action of torpedoes by numerous compartments and cellular subdivisions, these latter being filled with cellulose if found desirable. The vessel is designed of this size, both for purposes of protection and to enable her to carry an ample coal supply, and a very large supply of ammunition. The shell to be used will be 8-inch sub-calibre carrying 100 lb. charges. It is contemplated carrying about 1,200, which will suffice for countermining a channel 7 miles in length and 100 yards in width. Besides the explosive torpedoes, there will also be some buoy shell arranged somewhat like the explosive shell, but having no charge. Upon striking the water, the head is made to detach, and going to the bottom, enables the body to float and serve as a buoy, being attached to the latter by a wire rope. This buoy can be made to serve as a light, on striking the water, so that the countermined channel can be advanced over at night, if desirable.

Three guns are to be mounted forward, and abreast of each other as in the "Vesuvius;" but the middle gun, however, is to be fixed in direction, but may be elevated, whilst the two outer ones will have a slight lateral train. The mode of operation will then be something as follows:—The vessel being brought to anchor (preferably at night), at the outermost position at which it is deemed advisable, the guns being at the same elevation and the valve setting the same, the outer guns are placed at such an angle, as to direction with the middle gun, as to land the shell 100 feet on either side of the shell from the latter, at the extreme range determined upon—this may be 2 miles or even more, if necessary. The guns and valves are then set so as to throw the next set 100 feet *nearer* to the countermining ship. When at least ten sets of these have been thrown, a buoy shell may be fired from the middle gun to attain the same range as the set first thrown. By commencing at the longest range, and working backwards towards the countermining ship, the greatest economy of the compressed air is obtained and the largest number of rounds can be fired continuously. The vessel can be maintained in the desired direction either by anchors, on either side, and suitable warping arrangements or by side hydraulic jets.

Not alone will the countermining shell act directly in breaking up and exploding the fixed mines and cables, but the upward lift of the great wave formed by the simultaneous explosion of the three shells will be likely to tear the buoyant mines and circuit-closing buoys away from their moorings.

The countermining can be easily done at the rate of 1 mile in two hours, and even more rapidly if desired. It is true, as it will be said, that the besieged will not permit this operation to go on unmolested, but that may be said of any other method of countermining attempts. The countermining vessel must be guarded from the attacks of the enemy's torpedo-boats and possible attacks by dirigible torpedoes, trusting to the character of her armouring as protection from an occasional hit by the enemy's guns. No operation of war is likely to be entirely one-sided, and it is only possible to so arrange them that the *chances* of success are of the best. Is there any known method of countermining which is more rapid, certain, and feasible than the one now proposed?

A vessel armed as this is, will, as pointed out by Commander F. M. Barber, United States Navy, be most valuable for high-angle fire essential for the successful attack of modern sunken emplacements. Regarding this, Commander Caspar Goodrich, United States Navy, in a report on the bombardment of Alexandria, states the following conclusion:—

"*If Admiral Seymour had possessed a vessel carrying both heavy, modern, high-powered guns and large howitzers, or other shell guns capable of great elevation, and thus somewhat similar to the mortar in applicatiou, she would have been of immense value, for she could* have run close into the forts. With the shell and machine guns she could have driven the Egyptians away from their batteries, dismounting the latter with comparative ease at short range with her powerful ordnance. Valuable as Gatlings and Nordenfelts may be, under certain circumstances, it cannot be denied that they lack the moral effect of well-burst shell. Something approaching vertical fire must be secured for operations of this nature. . . . The necessity of a thorough determination of the possibilities of vertical fire must be patent to the most careless reader of this report. It is hardly an exaggeration to suggest that of all the directions open to the development of ordnance at the present time, this is by far the most promising and important. The writer feels strongly, not to say imperative obligation of working out this problem under the new conditions of the moment, and unhesitatingly recommends it as worthy of serious consideration and practical investigation."

Light Buoys.

Should the light buoy shell be made to operate successfully, they will be of use for the defence both of shore batteries and ships at anchor, having many advantages over the electric search lights. These last indicate the position from which they are used, and not infrequently aid the attack without assisting at all the defence. In the case of a ship at anchor, she might surround herself by a cordon of these light buoys, say at the distance of one mile, with some on an interior line. The defenders will be more likely to perceive the approach of an enemy's torpedo-boat by means of the diffused light over a large space, than by the blinding concentrated ray, reaching only a single narrow sector or zone, making more intense the surrounding darkness. Not alone will these light buoys serve to make visible the approach of the enemy, but will also give, from their relative positions, and the accuracy with which the pneumatic shell can be projected, a close approximation to the range. Similarly, from shore defences these light bnoys may be thrown, and serve to illuminate the approaches. These buoys when fired from the 15″ gun, can be made to burn about two hours. A very large light ball shell can be used with effective lighting possibilities from the pneumatic gun.

Use for Defence of Ships against Torpedo-boats.—Dirigible Torpedoes and Submarine Boats.

The present *active* defence of a man-of-war against torpedo-boats is dependent on absolutely hitting a *small* and rapidly moving object. This is somewhat difficult of attainment. With the shell from the pneumatic gun an absolute hit is not required. The hulls of torpedo-boats are so slight that a pressure of say 1,000 lbs. per square inch would be enough to disable them, if not to absolutely disrupt them.

A shell with 100 lbs. will effectively *stop* the approach of the enemy's torpedo-boats before they can discharge their Whitehead torpedoes, even when the explosion takes place at a distance of more than 50 feet from the boat, if General Abbot's formulæ are correct.

Again, should the enemy's torpedo-boats succeed in discharging their under-water movable torpedoes (such as the Whitehead) the present armament of a man-of-war is incapable of stopping them in the least, unless the wire protective nettings are down, and even this may not always suffice. These nettings, however, are not always down, and cannot be put down if the vessel is meant to retain her full manœuvring power. The prompt use of a small rapid firing pneumatic gun might afford a chance in this direction, as its shell would burst under water, and have a large effective radius, in a field where the ordinary powder gun projectiles cannot be effective. There is also a chance of stopping dirigible torpedoes such as the "Patrick," "Sims," and "Brennan," by this means. Besides the possibility of injury to the hulls of these torpedoes and the delicate machinery contained, all of these may be rendered innocuous by injury to the long wire on which they are dependent for manipulation and life, and the shell would be effective in exploding either directly ahead, abreast of, or a very considerable distance in rear, in the line of movement of the torpedo.

A pneumatic torpedo-gun of comparatively small calibre as dirigible as the rapid firing Hotchkiss is being designed for this purpose.

Submarine boats will doubtless be important factors in future naval operations and combats. Their presence and approach may sometimes be detected by bubbles and other indications. In the experiments already made with the Nordenfelt submarine boat, although it was so far submerged that no part of the ordinary armament of a man-of-war could have stopped it in its approach and attack, its presence was detected; it could easily have taken up a position within 300 yards, at which distance it could discharge its Whitehead torpedoes with some approach to accuracy. But a vessel armed with pneumatic torpedo-guns could send its shell into the water over or in the vicinity of the attacking submarine boat. The explosion, being regulated to take place when the shell was completely submerged, would inevitably end the career of this submarine boat.

A distinguished naval Officer has said, on the floor of this Institution, that the pneumatic torpedo-gun is purely a defensive weapon, and that Great Britain needed none such. This does not appear to be concurred in by the nation at large, if one may judge from the public discussions, the efforts, and expenditure made in erection of defensive works along the extensive sea coast of Great Britain. Neither is it borne out by the results of the naval manœuvres of the last two years, if these last have been reported correctly.

Whilst audacity is of value in warlike operations, it is well to assume that the enemy may be equally audacious and equally able. A nation's defence must not be based on prejudices or preconceived ideas, nor is it wise to underrate the strength, courage, and ability of all possible opponents. What a British Commander has been able to do (I refer to Admiral Tryon in last year's manœuvres)

may sometimes be accomplished by others. No naval force, however large, is in itself sufficient to ward off the attacks of an enemy having an efficient enterprising naval force, from all of the important seaports. These must be so fortified that the *time* is given for the arrival of naval succour. It is almost an axiom that every fort may be taken, and the chief value lies in that the attacking party is delayed by them, and time is gained for the concentration of the resources of the defence. With the sea-coast well defended on land, aggressive action on the part of the naval forces becomes more feasible.

Assuming for a moment that the *rôle* of a nation, in case of war, is to act purely on the offensive by its naval forces, the pneumatic torpedo-gun affords the best facilities for the countermining operations which the attack must resort to.

Let us imagine that the enemy's naval force will stand to fight, and, while equally well armed as to guns and ordinary torpedoes, his ships have a few pneumatic torpedo-tubes. Might not some of these chance to launch their aërial torpedoes effectively, and put to nought the armament, skill, and audacity of your own forces? We might even reasonably imagine that one of your leviathans might be attacked and *sunk* by a much smaller and less expensive armoured vessel of suitable design, having equal or greater speed and manœuvring ability, armed with rapid-firing pneumatic torpedo-guns.

Although it is frequently said, even now, that the pneumatic torpedo-gun is in an experimental state, may that not be said of every weapon that is in present use? Who will be so rash as to say that any of these have attained the ultimate of their development and possibilities?

But whether in an experimental state or not, it has successfully thrown with accuracy, and to distances unattainable by other torpedoes, very large charges, and it is capable of sinking therewith the most powerful and best protected war vessel afloat.

The CHAIRMAN: Gentlemen, I am afraid this is a subject which we are not very competent to discuss, but it is just possible there may be gentlemen present who would like to ask the lecturer some questions, and he has already told us how happy he will be to give every information to any present who desire to have detailed answers upon any special points that interest them.

Admiral COLOMB: I really do not know enough about the subject to ask questions, but I imagine that just towards the close of his lecture Captain Zalinski has referred to some expressions of mine made in this theatre, and I may perhaps be allowed to clear up that one point. He says that it has been stated on the floor of this Institution that the pneumatic torpedo-gun is "purely a defensive weapon, and that Great Britain needed none such." What I meant was that as it was then presented to us, it was in the same category precisely as the Brennan torpedo. I should just like to ask the lecturer whether any experiments have been made at sea, and whether the accuracy which seems undoubtedly to be got from a fixed platform can be got from a floating platform, because, of course, if that is the case, the weapon ceases to range itself beside the Brennan torpedo, and takes the character of a general weapon, which may go to lengths that I do not think any of us can predict. I regret that not knowing more I cannot ask more questions, but that really is the only question that has struck me, whether practice has been made at sea, and what proof you have of accurate practice in a sea-way.

Captain ZALINSKI: Unfortunately we have had no practice in that direction, but

I have given in the course of my paper the reasons why I expect more than ordinary accuracy. Of course the fact that the same degree of accuracy is not attainable with either ordinary powder guns or torpedoes afloat as ashore is owing to the firing from an unstable platform. When the range is found by range-finders, the chance of obtaining results with the pneumatic gun is very much better than I think is possible for torpedoes in ordinary practice, or even by ordinary guns. I hope before long that we shall have experimented further in that direction, but it seems to me that the physical conditions involved are such that the chances of accuracy of fire are more than fairly good.

Admiral BOYS: My Lord, perhaps the lecturer would be kind enough to tell us if a practical trial has been made with training gear fitted to this weapon afloat. The length of the "Vesuvius" is stated to be about 230 feet. Now most naval men would agree that it is very difficult indeed to point a ship by a rudder when that ship is 230 feet long. When in former days experiments were tried with guns fixed in vessels to train by steering in a much shorter ship than that, the conclusion arrived at was that 90 feet length was almost the limit of management for pointing by the rudder. Perhaps I may take this opportunity of making a remark about the observation made by our noble Chairman respecting the Council of this Institution not having put off to-day's meeting. I may explain that the fact is that our days have been so very much engaged that there was really no other day on which we could conveniently have had this lecture, that is the reason it was fixed upon.

Captain ZALINSKI: It is perfectly possible to arrange the gun so that it can be trained. In fact, vessels have been designed to allow guns to be trained in them, but it was thought good results would be obtained in this way; in fact, we have experimented with the "Vesuvius" when the weather was comparatively rough, and having selected as a target the mast of a vessel, steering directly for her, so steadily that I should have deemed myself criminal if I had not hit a first-class man-of-war twice out of three times, at a range of one mile.

Captain JACKSON: Has the range-finder been tried, and is the base found sufficient for that gun? Have you got satisfactory results with it?

Captain ZALINSKI: That also has not been tried afloat, but it has been tried under conditions as nearly analogous as possible. The base-line of 26½ feet has been found to give accuracy within 1 per cent. at ranges up to 2,600 yards. I have indicated that these ranges are obtained almost instantaneously. The first range may cause a delay of five or six seconds, but after the range is once obtained, the indication is almost continuous.

Lieut.-Col. WALFORD, h.p. R.A.: I may perhaps be allowed to ask one or two questions. I wish particularly to know, with regard to the shape of this shell, how the forward position of the centre of gravity affects the drift? In an ordinary gun the shot drifts to the right; perhaps the lecturer will kindly tell us what is the case in the pneumatic gun? I should wish also to ask how the shape of the shell affects its movements in wind, particularly in cross winds? The centre of gravity is so far forward that a large space is given for the wind to act upon in rear of it, and I should be glad to hear whether, owing to this fact, the shell tends to turn up into the wind, or to turn away? Then another point is the question as to how long the pressure can be kept up? Of course, as each charge is let off, there is a certain amount of pressure withdrawn from the cylinder which must be replaced, or there will be a tendency to fall off from the original velocity. This point has, I think, been hinted at by the lecturer since, when, in clearing a channel through a mine-field, he proposes to begin with the longest distance. I further wish to ask what is the muzzle velocity of the shell? As far as I can work it out, I take it to be 600 foot-seconds. Assuming that to be correct, I should like to ask whether any experiments have, to the lecturer's knowledge, been made with powder-charges throwing high explosives at so low a velocity? My impression is we have always tried to give a much higher velocity. The lecturer has told us something about the trial against armour, and has mentioned that the plates used were laminated, consisting of six small plates of a total thickness of 4½ inches. I think most of us who have worked at armour will say that it is scarcely a test, as the plates were of so small a thickness, while the metal cannot have been of very good character, since a 30 lb. shell with, I assume, a muzzle velocity of 600 foot-seconds, could

make an impression $2\frac{1}{2}$ inches deep in it. As a matter of fact, very little is known of the effect of high explosives against armour, but I must confess myself that what the lecturer has told us does not convince me that the gun would be useful against the upper works of an armoured ship. I thoroughly believe in it as a torpedo working under the sea, but not as against thick armour. There is one other question which I may perhaps ask. A table of effects of high explosives against armour plates is given in the paper, together with a formula, $W = 3{\cdot}3d$; I cannot make these agree at all; d^2 seems to work out fairly well, but it does not appear from this table that the penetration can be in proportion to the weight, as it would be if the formula were correct?

Captain ZALINSKI: I do not know that I have all the points noted down consecutively, but I will take them as I happened to get them. As to the armour experiment, it was not for a moment intended to indicate what the explosive could do; the experiment was simply to try and show the *relative* effect of a shell charged with sand, a shell fired with an explosive by impact, and one exploded from the rear. It was not claimed that a laminated plate would be as good as a solid plate. As to the effect against armour, I tried to indicate that the gun was not intended for armour piercing or for direct attack upon the over water hull, but that there are possibilities of doing this very considerable damage. The formula referred to has been one that is considered simply as an approximation, the only thing attainable. It should read $W = 3{\cdot}3d^2$. I do not know that I made it clear, but it was for explosive gelatine, taking the strength at 142 as against 100 of dynamite, and from that, I think, if you apply the formula, you will find the figures I give are approximately correct. I do not at all swear by that formula, but it is the only thing applicable. I should very much like to try the gun with heavy charges against armour, and produce better formulæ. I hope that may be possible when the gun is brought to Shoeburyness. I tried to get armour furnished for that purpose, but the Government did not seem inclined to expend money at that time. As to the velocities, the velocity of the 500lb. shell is about 600, between that and 650; whereas that of the 8-inch sub-calibre will be something over 1,000. As to the drift, it seemed to me that, so far as I have gone, if anything it is a reversed version of what is expected of an ordinary rifle projectile. When expected to go to the right, it seems to move to the left, but not very much. As to the effect of wind, we rather expected the deflection might naturally work into the wind, the centre of gravity being so far forward; but, on the contrary, it seems to have a very regular lee-way, as it were carried off by the wind, and so regularly that I can allow for it absolutely upon the first fire. The shooting has been accurate even under unfavourable conditions of wind. I use a method of my own in making allowance for wind, resolving it into its rectangular components with reference to the line of fire. I find the deflection produced per given range for 1 mile of wind at right angles to the line of fire, and, applying that, I can get my sight very nearly covered for the first time. The deviation due to the wind is not what might be expected, and it is so regular that accurate shooting can be done under rather unfavourable conditions as to wind.

Major-General W. H. GOODENOUGH: I think you told me you had applied a system of resolving the force of the wind into its rectangular components for rifle fire and found it very readily understood and taken up.

Captain ZALINSKI: Yes, we found that.

Major-General GOODENOUGH: I thought it might be interesting that this should be known.

Captain ZALINSKI: We have found that to be the case and it is now embodied in the "Target Record Book" and "Rifle Manual" issued for the Service. In a recent order from Headquarters of the Army upon the subject of artillery instruction, you will see that the instruction as to estimating the velocity of the wind and to resolving it into its rectangular components with reference to the line of fire is embodied as part of the instruction of the artillery of the United States Army. It no longer need be a matter of guesswork in adjusting the sight for wind deflection. There is no need of feeling your way and trying two or three shots, which is sometimes expensive and leads to loss of time. By applying it you can get a perfect line on the first shot.

Major-General GOODENOUGH: That might be particularly applicable in high-angle long-range fire.

Captain ZALINSKI: I should think it might, but I have not tested it sufficiently, because under some conditions the higher strata of air might have different velocities; although in my experiments I got that by flying a kite having little toy balloons attached to different parts of the string. In this way I could judge of the direction of the higher strata. But the experiments were not carried to a definite conclusion.

The CHAIRMAN: Well, gentlemen, as no one else seems anxious to ask any more questions or to continue the discussion, I think we may bring our proceedings here to-day to a conclusion. The subject is, of course, entirely a novel one to all of us, and it is therefore very natural there should not be any one here, or perhaps even in England, capable of asking either intelligent questions or continuing an intelligent discussion upon this most interesting subject. I can assure the lecturer we shall all look forward with the most intense interest to those experiments which are about to be carried on at Shoeburyness with this gun. I think every one who takes an interest in gunnery, and I may say in both the Army and the Navy, has read with intense interest the reports which we have received from America of experiments carried out under the lecturer's care and guidance. I have read those reports with the greatest possible attention, and it has struck me on reading them, as I said in my opening remarks, that the development of this new implement of war is very likely to create a new departure in warfare both on sea and on land. I look forward, therefore, with very great interest to the experiments at Shoeburyness, and I hope if those experiments are successful—and I have every reason to believe that they must be, judging from the narrative of what has taken place on the other side the Atlantic—that we may not be backward in providing ourselves with a certain number of these guns for our own use in both the naval and military services. It now only remains for me to thank the lecturer for his great kindness in coming here and for giving us this very interesting lecture. I beg to assure him as I did before of my extreme regret that we have not had a larger audience. I hope he will understand that that fact is entirely attributable to the attractions of this week, owing to the great number of people and the large show of troops in the streets assembled to greet the great foreign potentate who has done us the honour of paying us a visit. Had it been otherwise, I am sure this lecture hall would have been as crowded as it has been upon previous occasions when Officers of other armies have visited us. I would beg to assure him in your name how very grateful we are to him for having come here; and we hope it may not be the last time that we shall be honoured by the presence of an Officer of the United States Army lecturing in this hall.

OCCASIONAL PAPERS.

This portion of the Number is reserved for Articles, either Original or Compiled, on Professional Subjects connected with Foreign Naval and Military matters; also for Notices of Professional Books, either Foreign or English.

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THE PHOTOGRAPHING OF ARTILLERY PROJECTILES TRAVELLING THROUGH THE AIR AT A HIGH VELOCITY.

Translated from the *Deutsche Heeres-Zeitung* by Commander H. GARBETT, R.N.

IN September last year some very interesting experiments were carried out at the range of the Grüson iron factories at Buckau Magdeburg by Herr Ottomar Anschütz, the well-known expert in instantaneous photography of Lissa (Posen), which proved by some successful impressions the possibility of photographing projectiles from artillery during their flight at high velocities. It is the first time within our knowledge that this problem has been attempted at all and at the same time solved.

Herr Anschütz by these experiments only wished to demonstrate that it is generally possible during the flight of a projectile to fix its image by daylight sharply upon a photographic plate, and this not only once but in several consecutive phases, the number of which has been temporarily fixed at four. As these experiments were carried out at his own cost, Herr Auschütz found it necessary on account of the expense to limit in many respects the various ways of applying his method.

In taking impressions of bodies which are moving with great velocity there are two difficulties to be overcome; the first, so to shorten the time of exposure that the object appears sharply defined; the second, to obtain the impression at the exact moment when the object arrives at a given point.

With regard to the first-named difficulty, it is easily understood that, with increasing velocity in a moving body, it is necessary to shorten the time of exposure, as, if too long, instead of a clear sharply-defined picture, one crooked and elongated in the direction of its line of motion would only be obtained. In taking an impression of a projectile in flight, it is also to be feared that one would find upon the plate not a picture of the projectile but one of its calibre. Herr Anschütz believes that for a velocity of about 400 metres a second, the time of exposure must be limited to the extraordinarily short space of the 76 millionth part (0·000076) of a second; the projectile would in that time travel about 3 centimetres, and he therefore hoped that if he could fix his apparatus at a proper distance, and consequently diminish the visual angle, the projectile would appear upon the plate suffi-

ciently sharply defined, or at most a little misty about the edges at the front and base.

In order to give the reader an approximate notion of what opening and shutting a photographic apparatus in the 76 millionth part of a second means, and during that time to take a distinct impression, it must be stated that in ordinary so-called instantaneous photography (of living moving objects, &c.) this time fluctuates mostly between the one-twentieth and the one-sixtieth part of a second, and has never as yet even been compressed within the one-hundredth part of a second.

The second of the difficulties already mentioned is known to any one who has at all busied himself with instantaneous photography; he will have learnt how difficult it is, for example, to fix in the exact centre of a plate a horse trotting past the apparatus, he generally exposes either too soon or too late. How much more difficult, therefore, must it be to deal with a projectile moving with a velocity of some 400 metres in a second, especially when the object field of the apparatus only covers about 15 metres. Herr Anschütz has, in order to meet the difficulty, so constructed his apparatus, that the projectile itself, by tearing away a wire net, and by so doing breaking an electric current, brings into action an instantaneous closing arrangement, and in this manner, have due regard to the time which the release and working of the arrangement requires, the certainty is offered that the projectile will pass the field of the instrument at the exact moment when the mechanism for the instantaneous exposure and covering of the plate is brought into play.

The principle of construction of such an instantaneous mechanism for work of this kind consists in the main, that a covering disc closing the lens, but provided with an opening at one spot, hangs before the apparatus; it is released by the breaking of an electric current, and when free must attain in falling that velocity, which is required to correspond with not only the velocity of the moving projectile but also the time of exposure rendered necessary by the sensitiveness of the plate, as well as the size of the opening, in order to obtain a clear picture of the flying projectile in the short time which elapses whilst the opening in the falling covering disc passes the apparatus. It is obvious that the bringing into agreement of all these factors, position and velocity of the flying projectile, the direction of the apparatus, point of time and duration of the exposure of the plate, create no light difficulties in the practical working of the scheme; and the completeness of any apparatus constructed for this purpose will be proved by its surmounting or otherwise of these difficulties.

For the case under discussion the question in the first rank is the determining the time which elapses from the release of the disc already mentioned till the moment when the opening in it passes the lens of the apparatus with the necessary velocity, in order to be able to determine the exact spot where the impression must be taken. By application of the spark chronograph this time proved to be 0·28 of a second; in this time the protectile with a velocity of 400 metres a second travelled over 113 metres, and therefore the position for taking the impression was fixed for 113 metres in advance of the frame of the wire net, by passing through which the projectile itself released the covering disc before mentioned. At the height of this distance it was therefore necessary to fix on one side of the path of the projectile a white background, against which the flying shot is shown in sharp relief, while upon the other side of the plane, distant about 80 metres horizontally from it, it is the position which ought to be assigned to the photographic apparatus.

Since Herr Anschütz intended to obtain an image of the shot at four different points, four apparatus were provided, which were so arranged that

each succeeding one worked 0·009 of a second later than the preceding one. For the whole set of impressions then 0·028 of a second was required, in which time the projectile would travel about 11 metres. The background was in consequence of these 13 metres elongated, and upon it, below the line of the projectiles, a scale 12 metres long drawn, so that it would be immediately seen where the moving projectile was at time of each impression. Beneath the centre and two ends of the scale three shot were securely suspended, in order to have a comparison of the pictures of the projectiles, both in motion and at rest, with each of the impressions.

Herr Anschütz had naturally so constructed his apparatus that it would suit any other approximately similar at least to those described, even if the conditions should be changed on account of the time of flight of the projectile; and it needs scarcely to be explained that in consequence of having to work with so minute a limit of time, an arrangement of the apparatus in connection with Siemens spark chronoscope was necessary to determine the fixing and reading off the smallest units of time.

Unfortunately the range of the Grüson factory at Buckau is extremely limited, so the experiments could not be carried out as completely as was intended. The working of the apparatus by the projectile itself could not be managed, as the distance of 113 metres for the projectile could not be obtained, and this was the distance necessary to correspond with the fall of the covering disc. As time was wanting, nothing else remained but to provide the necessary interval for the working of the instantaneous mechanism by arranging for the release of the disc at the beginning of the ignition of the charge, so that during its combustion the disc was already falling. By this arrangement it was necessary to take into account the irregularities which are unavoidable in the ignition and combustion of the charges of guns (which become of moment through the necessity which exists for the most exact agreement in the coming smallest particles of time); and so it resulted unfortunately that in two methods of ignition provided at the experiments, the one acted too slowly and the other too rapidly, with the result that the projectile had either not reached or else had passed the object field of the apparatus at the moment of exposure.

Nevertheless, he succeeded late in the afternoon in obtaining by means of the first apparatus a neat impression of a 25 centimetre long 8·5 centimetre projectile, and thereby proved the possibility of the experiment, although it was accidentally placed in a very unfavourable position in consequence of the position of a beam placed near, which threw a shadow upon the white background.

Unfortunately also the projectile had already reached the end of the object field, so that the remaining three impressions showed only the bare background with the scale and shot at rest.

Both by this one successful impression, as also by those attempts where the necessary agreement between the flying projectile and the working of the apparatus was not obtained, it resulted nevertheless, and this is conclusively the essential fact in regard to the photographic impressions, that with tolerably good sunlight even the uncommonly short time of exposure of 0·000076th part of a second suffices completely with an extremely susceptible plate to obtain clear pictures.

The moving projectile in the unfortunately only single instance of its impression shows in its picture, in comparison with that of the projectiles at rest, a scarcely noticeable indistinctness at both ends, which arises from the fact that, as has been calculated, the shot during the exposure of the plate to the light moved forwards about 3 centimetres. A staff to be shot away is placed before every projectile in the direction in which it travels, and is distinctly visible in all four pictures, indicating clearly in its different

assumed positions from its breaking and during its following fall, that the harmony of the four apparatus was complete and that they acted well.

The proof of the possibility of the experiment has thus been made. It is, in fact, much to be wished that Herr Anschütz should be placed in a position to continue his work much further; we should then receive more exact information in regard to the trajectories of projectiles on many points now shrouded in uncertainty. There is, no doubt, that this art of instantaneous photography, which is still in its infancy, is destined under skilful hands to undergo large development, which will place the whole science of ballistics upon a more thoroughly secure foundation of experiment and tangible fact, than the airy and hypothetical grounds on which it now rests.

Some time ago Professor Mack, of Prague, succeeded in photographing rifle bullets in motion quite distinctly by help of the Töpler-Schieren method, which is the result of experiments carried out during many years by Dr. Töpler, one of the professors at the Polytechnikum at Dresden, with various lenses, in order to bring under proper examination rays of light under different phases of refraction, and by this means it has been rendered possible to examine the cushion of air which surrounds a projectile flying at a high velocity. These bullets were fired in a darkened room, and in consequence of their small range offered the advantage, that a momentarily appearing electric spark could be used as a source of light; with such an arrangement naturally the complicated mechanism for bringing the time of exposure of the plate into agreement with the flight of the projectile becomes quite superfluous, as the open apparatus can only receive the impression during the short moment in which the electric spark conveys the light to it, while simultaneously illuminating the bullet flying past it.

Whether a corresponding arrangement can be made applicable, and an electric spark suffice to illuminate sufficiently artillery projectiles must reasonably be doubted; fortunately Herr Anschütz's experiments have shown that as simple a method for photographing large projectiles exists, and that not only distinct impressions of the projectiles in motion can be taken in series, but also simultaneous impressions of one and the same projectile at the most different points of its path, at the moment of its striking and penetrating armour, and in the case of shell at the moment of bursting.

We hear that Herr Anschütz has had the honour of laying before the Kaiser at Müncheburg on the occasion of the manœuvres his first successful impression of a projectile in flight. May this be a good omen for the further progress of its efforts, and may also the necessary means not be wanting for the carrying on of his important and costly experiment.

H. G.

THE DRILL REGULATIONS OF THE GERMAN FIELD ARTILLERY.

Translated by Lieut.-Colonel WALFORD.

PART IV.—THE FIGHT.[1]

.1 *Introduction.*

IN order to ensure uniformity with the conditions of war it is necessary, while carrying out the Exercises, to pay careful attention to the correct choice of formations with reference to the special duty of the moment, and at the same time to take advantage of the character of the ground. The selection must be such as will tend to give the greatest effect to our fire, and to diminish the value of that of the enemy.

It must be remembered that the formations and principles laid down in the Regulations take into consideration only the most simple conditions, and that when applying them before the enemy, circumstances will often necessitate some change in them. As such a change may result at any moment from an alteration in the character of the action, all commanders, in their several positions, must be practised in accommodating their orders, quickly and without hesitation, to the phase which for the time being may exist, and must ever feel convinced that *omission and neglect are far more injurious than any mistake in the selection of the form of action.*

In accordance with the general principle of advancing from that which is easy to that which is difficult, all Exercises are to be carried out (assuming some simple tactical condition), first in the battery and afterwards in the brigade-division and larger units ; also at the commencement over open and easy ground, and finally in difficult country. Complicating circumstances of all kinds, especially the conduct of an action under conditions involving heavy loss, are to be gradually taken into account.

2. *Division of Command.*

The commander of a force of artillery which is attached to a body of troops will, up to the beginning of the fight, remain with the commander of that body. He will then take over the command of his force (or of the larger fraction of it, if it be broken up), but will, nevertheless, keep up continual communication with the commander of the troops.

If during the course of the fight any batteries or parts of batteries come into action on a position where a brigade-division or battery which belongs to another unit is present, they will, until a change of position takes place, pass under the command of the commander of the said brigade-division or battery.

On the same principle, batteries which belong to a cavalry division will, when they are employed in combination with other artillery, pass under the command of the senior artillery Officer on the spot.

The battery will always, the brigade-division will only as far as is convenient, be worked by words of command, trumpet-calls, and signals. When a yet larger unit is employed, directions and orders will take their place.

Trumpet-calls are to be used as little as possible.

Every Officer and non-commissioned officer is, as a special duty, to provide

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[1] Continued from No. 149.

for the *immediate* execution, within his command, of all orders relating to halting and forming line.

For the carriage of the more important verbal orders, Officers are, whenever possible, to be employed ; otherwise orderlies may be used. The latter must, however, be so far advanced in their training that they can understand the sense of such orders as they receive.

3. *General Principles.*

The Field Artillery will usually open the battle. It is thus, in most cases, of importance to deploy at the very commencement a *superior number of guns*, and to be in a position to early develop an *effect in mass.*

Artillery will, as a rule, be used in units of brigade-divisions or regiments ; the employment of individual batteries will be the exception. Only under very special circumstances should a battery be broken up.

Since the *choice of the first artillery position* is frequently decisive as regards the deployment of the whole force, but is also always dependent upon the intentions of the commander of the troops with respect to the action, the Officer commanding the artillery must take his orders with regard to it, and also as to the strength of the unit of artillery which is to be first brought up.

The *fire-effect of artillery* should undoubtedly be principally used at ranges which lie *beyond the zone of the effective fire of infantry ;* but it must be remembered, as a principle, that the latter can never dispense with the aid of artillery. For this reason the *artillery should not, at decisive moments, avoid even the very heaviest infantry fire.*

A *special escort* for artillery is not usually requisite. It is the duty of any bodies of troops which may happen to be in the neighbourhood of a threatened battery, to give it their aid.

A *battery which has expended its ammunition* is not to retire ; it is to wait in its fire-position until fresh ammunition has been brought up.

Batteries which are under fire are not to be withdrawn, but are to be reinforced by the advance of fresh ones. Even very heavy loss affords no reason for the abandonment of a position.

As a matter of principle, movements *in retreat* are to be begun *at a walk.*

It is often impossible to avoid firing over our own troops, but this is nevertheless only to be permitted when the artillery commander, after a careful estimate, is convinced that there is no risk in it.

In addition to the precautions taken by the other arms, artillery must guard itself against surprise. This is especially the case with regard to a flank left unprotected after the fire-position has been taken up. Every flank battery is, without any special order, responsible for due observation on the flank.

Horse Artillery batteries are particularly suited for quickly supporting any threatened point, or for taking advantage of a favourable phase in the action.

4. *The Assembly.*

The choice of the formation for the assembly will be governed by the proportion of the force to that of the other troops, the available space, the character of the ground, and the need for supervision.

If the 2nd Line of wagons is with the battery, the battery commander will direct whether it is to stand on the flank or in the rear of the fighting-battery. In the case of larger units the senior commander will regulate this question.

5. *The Choice of the Fire-position.*

Every *artillery position must be reconnoitred by the commander, who must hasten on ahead for this purpose.* He must take care that the attention of the enemy is not prematurely drawn to the position which is to be taken up. The actual inspection of it should, under certain circumstances, be carried out on foot, or such persons as accompany him should at least be left behind.

In the case of a *retirement* an Officer is to be told off to inspect the new position; he will receive general directions from the commander, who will remain with the guns.

The *selection of a correct front* is of particular importance, since a change of front by artillery which has once taken up a position, breaks off the fire, and can frequently, especially when the line of guns is of great length, be carried out only with considerable loss.

When selecting a position considerations respecting the effect of fire are, as far as possible, to be taken in conjunction with those affecting cover; but of these the former are the more important.

The first necessity is an extensive and open field of fire, together with ample space; it should, for choice, be possible to command the country up to within the shortest ranges, and we further need level ground for the guns, facility for supervision, and a line of front not too irregular, and as nearly as possible at right angles to the line of fire.

The most advantageous position is one in rear of the crest of heights, such that the muzzles of the guns just overtop it; the 1st Line of wagons should be in rear and, whenever practicable, under cover in rear of a flank.

Wet or broken ground before the front is favourable, if it does not seriously affect our own power of movement.

Screens are advantageous only when they are at least from 100 to 200 metres in front of the battery.

It is a disadvantage to stand in the immediate neighbourhood of particularly conspicuous objects, or a little in front of them, since they aid the enemy to observe his fire.

Positions for the guns which rise considerably to the rear assist, especially on hard ground, in diminishing the recoil. If such positions cannot be found, the brakes, must, as an exception, be used; but they tend to wear out the matériel.

Earthworks to give cover (especially to the men) from the enemy's fire, are always useful, when time permits of their construction. They should be used on a large scale in positions prepared beforehand for defence; cover for limbers or ammunition wagons can be employed only in positions prepared long beforehand, or in siege warfare.

Battery intervals of from 30 to 50 paces are advantageous to the conduct of fire. If necessary the gun intervals may, in order to permit of their use, be first reduced to the minimum of 10 paces.

Even larger intervals are desirable between brigade-divisions.

It will be necessary, particularly when in great strength, to pay attention to a *similar diminution of the extent of front,* as only thus can sufficient space be obtained, without mixing the various artillery units, for the batteries which will come up later.

The posting of several batteries in line or echelon will be governed by the character of the ground, by the direction of the wind, and frequently by the estimated course of the action. If space be wanting, it may be of advantage to place a second line of guns in rear of the first, if the ground allows of such an arrangement.

The conduct of fire should not be made more difficult by placing the echelons too far apart. The intervals between the echelons must not be so

small as to ead to any risk to the foremost lines ; they may, nevertheless, be considerably less than the distance between them. When the numbers are large, it will, in most cases, be necessary to echelon by brigade-divisions.

The use of echelons is favourable to the conduct of fire, if the wind blows the smoke *in rear* of the nearest echelons.

6. *The Advance into the Fire-position.*

Every portion of ground which has to be crossed must be *reconnoitred with respect to the enemy, and also with regard to the possibility of traversing it.* Even though the former is, strictly speaking, the work of the other arms, yet the duty lies with the artillery to protect itself by its own reconnaissances against any attack by surprise. Reconnaissance with respect to passability is certainly the duty of the Field Artillery itself, and falls to the share of the leading battery, so long as the several batteries are one behind the other.

The scouts told off for this purpose must remain in close communication with the battery, and must immediately report anything of importance which they observe, or must convey this information by preconcerted signals. In addition to such general care, particular attention must be paid to the direction in which fire is to be opened, &c.

Roads are to be used as much as possible for the advance. A simultaneous advance by parallel roads is advantageous, as is also, when it is practicable, the shortening of the column of march by the use of section-column.

When advancing into position especial attention must be given to taking advantage of cover. With this object it is frequently advisable to move in battery- or brigade-division column until close up to the actual position.

When an approach under cover is not possible, artillery will advance in line against the enemy. A uniform mode of procedure among the batteries is not necessary.

If possible, the batteries will form line beyond the reach of the enemy's fire or behind cover. Repeated changes of formation must be avoided.

For flank movements under the enemy's fire (which as far as possible are to be avoided), the best formation is the battery-column.

The *paces* to be chosen depend entirely upon the intentions of the commander, the condition of the action, and the character of the ground. The main point is the consideration that the horses will have done all that can be asked, when they have brought the guns into position, even if to do so requires the expenditure of their last effort.

Especial importance is to be attributed to a *covered advance into position*, and to *an opening of fire*, which shall, as far as possible, *surprise the enemy*. Where there is no cover available, this effect must be obtained by rapidity of movement.

Under certain circumstances, and in order to provide for the simultaneous opening of fire, and for quiet and order while moving into the fire-position, a *preparatory position under cover* may be first taken up. The nearer this is to the rear of the fire-position the better.

No binding rules can be given for the formation of the batteries in the preparatory position.

All preparations for action, such as loading the guns (if by any chance this has not already been done), setting the tangent scales, clinometers, &c., will be made in the preparatory position ; moreover, the section- and gun-leaders and the laying numbers may be there instructed as to the next task of the battery, if this can be done without attracting the attention of the enemy.

The movement from the preparatory position into the fire-position must be made rapidly, and as far as possible on a full front, in order to surprise the enemy.

Batteries which come up later into action must, on level ground, avoid as far as possible *coming into position close alongside or in line with a target, on which the enemy has already ranged himself.*

When it is intended to advance, the artillery commander must decide, taking into consideration the ground and the condition of the action, at what moment he will call up his brigade-division or battery commanders. The latter especially should not be called up sooner than is absolutely necessary to enable them to receive instructions. When a preparatory position is taken up, the battery commanders should not be summoned until the batteries have occupied it. The battery commanders will, either personally (dismounted) or by a dismounted subordinate, ascertain whether from the selected fire-line the target can be seen over the sights with the tangent-scale down.

The commanders, who have ridden on in advance, *remain in the selected position* and watch the enemy, while the *battery commanders, as a rule, themselves bring up their batteries into position.* Whether and how the chosen position is to be indicated, is settled according to the circumstances of the moment.

When the nature of the ground renders necessary a careful choice of position for each gun, the gun-leaders may be taken beforehand for this duty, if it can be carried out without attracting the attention of the enemy. The gun-leaders (dismounted) seek for the most suitable posts for their guns. Equal intervals between the guns are not necessary. The section commanders remain with the battery: the gun-leaders (dismounted) wait for the battery to come up, and give their guns the words of command to halt and come into action.

Coming into action to a flank has many advantages with respect to making use of the character of the ground. Under certain circumstances the guns may be reversed, even when advancing, and be brought into action rear. It may also happen that it may be desirable to use various methods of coming into action in one and the same battery.

When the position is on a height, the crest should not be approached before opening fire. The guns will, after coming into action, be run forward simultaneously until the target is visible over the sights with the tangent-scale down.

Direct fire is to be preferred to indirect; but the latter must be used when the ground or the phase of the action does not permit of direct fire.

7. *The Renewal of Ammunition, and the Conduct of the Limbers and Lines of Wagons.*

The punctual supply of ammunition is of the highest importance. It is carried out from—

1. The limbers.
2. The 1st Line of wagons.
3. The 2nd Line of wagons.
4. The nearest ammunition-columns.

The ammunition for the first rounds will be taken from the limbers. If the ammunition-wagons have come up to the guns, the limbers will, as a rule, be sent back at a walk to the 1st Line under command of the quartermaster-sergeant; they will there be refilled with ammunition when the wagons come up from the 2nd Line.

In the case of fire-positions, which there is every reason to suppose will be occupied for only a short time, the limbers may, as an exception, remain with the guns, and the ammunition-wagon with the first line.

The 1*st Line*, and the *limbers* which have been sent back to it, will, if possible, be placed under cover from the enemy's fire, or at least from his

view. If no cover can be found, a position will be chosen about 200 metres in rear of the fire-line, such that the effect of the enemy's fire, when ranged on the guns, may be to some extent avoided. A greater distance than this is not advisable, as in case of need the limbers must be close at hand.

No exact rules can be given with regard to the position in open ground; but close formations should not be used. In most cases the column of route will be advisable, and a position to the rear and flank of the battery.

When behind cover any formation may be taken up; as an exception the limbers may even be separated from the 1st Line, provided always that they can get to the guns quickly and without crossing each other.

The position of the 1st Line will be ordered by the battery commander. If in the course of the action it is necessary to change this position, his orders are to be taken in the matter.

If the batteries are fighting in brigade-division, the brigade-division commander gives general directions with regard to the positions of the 1st Lines; under certain circumstances they will be collected in one place. The battery commander attends to the selection of the actual spot which is most suitable.

During an ordinary march (Reisemarsch) the 2nd Lines remain with the batteries.

When an engagement is probable (Kriegsmarsch) they will be collected by brigade-divisions under an Officer, and will march immediately in rear of the independent unit, *e.g.*, the advanced guard, the corps artillery, &c.

Carriages belonging to other bodies of troops may be attached to these Lines in the case of cavalry divisions only.

Under special circumstances the 1st Line of wagons may be strengthened by the addition of some ammunition wagons from the 2nd Line.

As soon as the 2nd Line is separated from the batteries a non-commissioned officer of that Line is to be told off to the brigade-division commander for the purpose of carrying orders.

The brigade-division commander is responsible for the punctual arrival of the 2nd Line. He gives orders as to the point to which it is to advance, or, in the case of a retirement, to which it is to fall back.

But, on the other hand, it is the duty of the Line commander to bring up the wagons to the field of battle without any special order; in order to do this he must frequently display very great zeal and energy. He must report to the brigade-division commander his advance and his eventual position.

The 2nd Line takes up a post in rear of the fire-position; this should be easy to find and very accessible, and should have good communication by road with the batteries; this communication should, if necessary, be improved. But all main roads must be left free in order to avoid obstruction.

A safe distance for the position, of which nevertheless the selection must depend entirely upon the character of the locality, will be at about 800 metres from the fire-position. The formation which the 2nd Line will take up will be governed solely by the ground and by how best to take advantage of cover.

As soon as the 2nd Line has reached its post, the Line commander, unless otherwise ordered, will send up three ammunition-wagons for each battery to the 1st Lines.

The further renewal of ammunition from the 2nd Line is to be carried out under orders from the brigade-division commander. It is his duty to arrange, in good time, for the supply of everything which can be required by the batteries. Only such batteries as have their fire-position at an exceptionally great distance from that of the others, and who are for this reason specially named by the brigade-division commander, may communicate immediately with the commander of the 2nd Line.

The Line commander, so long as it is in his power, always sends to each battery the ammunition-wagons which belong to it.

Demands for ammunition from batteries which do not belong to the brigade-division, must be, as far as possible, satisfied by the commander of the 2nd Line; but he must at once report to the brigade-division commander *how he is situated with regard to this supply, and how many filled wagons he has with the 2nd Line.*

The empty ammunition wagons of the 1st Line fall back at once to the 2nd at a trot. As the commander of these wagons, and also of all movements of wagons between the two lines, each battery is, as far as possible, to make use of the non-commissioned officer who brought up the first three ammunition-wagons from the 2nd to the 1st Line.

The commander of the 2nd Line will send his empty ammunition-wagons by sections to the nearest ammunition-column to be refilled. He will be informed by the brigade-division commander with regard to the position of the latter; but it is, nevertheless, his duty to search for it himself.

If the course of the action necessitates a more rapid renewal of ammunition, full wagons may, as an exception, be temporarily sent from the columns to the batteries.

When batteries are acting independently, the renewal of ammunition is governed by the foregoing rules.

It is the especial duty of the commanders of lines and of sections of wagons to keep up the most perfect discipline and order. Any disorder among the carriages in rear of the line of battle may produce the most disastrous results by blocking up roads and defiles.

8. *The Conduct of Fire.*

The commander of the troops decides upon the object of the action, and, therefore, broadly, the target of the artillery.

The division of the target, in detail, among the several batteries, and the character and course of the action, are the business of those who conduct the artillery fire.

Without any consideration as to contingent losses, that target is always to be attacked which is decisive for the particular phase of the action which prevails at the moment.

At the commencement of the battle this will, in most cases, be the enemy's *artillery*. Fire will be directed first on those batteries whose effect is most felt, or whose successful silencing appears most easy.

If *infantry* form the target, then, unless large columns can be satisfactorily fired on, the enemy's firing-line should be attacked in such a manner, that as far as possible every portion of it shall be under fire.

Cavalry can, at long ranges, be effectively fired on only when they present themselves in masses. A charge must be beaten back by a rapid fire.

It will frequently be advisable to fire on the *staffs of the larger units.*

The effect of artillery will be much increased by the simultaneous and sudden opening of a well-prepared fire (which shall surprise the enemy), conducted by one head. If we require a quick and decisive result, we must combine many batteries against the same target.

In the brigade-division the fire will be conducted by the commander, but the independence of the battery commander is nevertheless to be preserved as far as possible.

It is in general impossible to avoid distributing the fire on several targets, as otherwise individual brigade-divisions of the enemy would be left in undisturbed activity. But such a distribution should never degenerate into a purposeless splitting-up of the fire, since superiority in the number of bat-

teries finds its effective expression only by means of the combination of their fire. Even where there is no superiority in strength, we must endeavour to obtain temporarily a crushing effect by concentrating the fire against a part of the enemy.

It is the duty of the battery commander to range the battery. The brigade-division commander will interfere only in rare cases, when he has convinced himself by trustworthy observation that the target which has been given is not properly understood, or that the ranging is incorrect.

The simultaneous ranging of several batteries on the same target is only to be allowed when the shots of the individual batteries can be clearly distinguished from each other.

Observation from a post on the flank may be of use. Recognised effect gives the most trustworthy information. The accuracy of the ranging may occasionally be judged by comparing the ranges, as found by the various batteries, taking into consideration the lie of the target and the position of the batteries.

When firing common shell, the limits of the bracket, as soon as it has been found, are to be reported to the commander of the brigade-division upon the prepared cards. In this case it is to be noted whether, and how many, "Aufsatzplatten" are used, whether the range has been found with the clinometer, and what is the angle between the line of sight and the horizontal.

Every battery which newly arrives, or which changes its target, must be informed by the brigade-division commander of the range which has been found.

All questions as to the target and range are to be addressed to a section commander, in order that the battery commander may not be disturbed in his conduct of fire. Attention to the words of command, and looking over a gun which has been laid, will frequently afford the required information.

The battery commander regulates the *order of fire.*

An economical use of ammunition is strictly ordered. The expenditure of ammunition and the rapidity of the fire are governed by the object of the action and the importance of the target.

In a delaying action the intervals between rounds will be lengthened ; but at the moment of the decision, or to take advantage of a passing phase of the battle, or in close fighting, they will be made as short as is compatible with a trustworthy service of the guns.

In "ordinary fire" a battery of 6 guns will, on an average, fire one round every 15 or 20 seconds.

Common shell are effective against all targets, but are least useful against firing lines lying down and targets which are under cover. They may be advantageously employed in ranging, and also against moving targets.

Shrapnel are adapted, owing to the great depth of their area of effect, for use against all living targets, and also against attacks at short ranges and targets which are behind cover.

Case serve for defence against an attack at short ranges ; and are effective up to 300 metres.

The *selection of the projectile* is the business of the battery commander. The brigade-division commander must nevertheless interfere under certain circumstances ; for example, he may direct a battery to continue to fire common shell, in order to obtain better observation of the shots, when several batteries are firing at the same target with shrapnel.

Every *change of target* is to be ordered by the brigade-division commander. Since as a rule a new ranging (which will take time) will be necessary, a change of target is not to be made until the desired effect on the former target has been fully obtained.

In the case of threatening danger the battery commander must order independently a change of target and of projectile.

9. *The Renewal of Ammunition and the Replacement of Casualties under the Fire of the Enemy.*

Every battery must, under all circumstances, bring the whole of its guns as quickly as possible into the fire-position. No attention is to be paid to injuries and losses which do not absolutely prevent the advance of the guns.

If a gun has become incapable of movement, the section commander is to give the requisite orders for it to be brought up, but is himself to go forward with the serviceable gun into the fire-position. The gun-leader of the gun which has been left behind arranges for the quickest possible restoration of its capability to move. Under certain circumstances it may have to be brought up by a diminished team, or even by the detachment alone.

Every battery which is under fire must, with all its power, and by the use of its whole matériel (including that of the 2nd Line), keep up a fire from every gun without cessation.

In a similar manner the mobility of the limbers is to be kept up by every available means.

The section commanders and the commanders of Lines of wagons give all orders needed for the renewal of ammunition and the replacement of casualties.

The detachments must be carefully trained beforehand in replacing casualties without orders.

If a battery cannot itself supply the necessary renewal of ammunition, the brigade-division commander shall arrange for assistance from another battery.

Even batteries which do not belong to the same brigade-division are, whenever it is in any way possible, to afford such aid.

10. *Change of the Fire-position.*

No change of position is to take place without the sanction of the Officer commanding the body of troops to which the artillery is attached; such permission may, in case of need, follow the movement. Only when the condition of the action calls for an immediate advance may this rule be neglected; in this case the independent intention is to be reported.

Small changes of position, which are necessary for this or that battery in order to obtain better effect or cover, are not considered as a change of position in the above sense.

Every change of position interrupts the effect of fire. Such a change is therefore to be made only when the object of the action demands it.

Before every change of position the guns are to be loaded with common shell.

It will be impossible, under certain circumstances, to avoid *taking batteries out of the fire-line,* in order to employ them in another position.

A single battery is to move as a whole into a new fire-position. If the collected force of artillery be stronger than this, it will, as a rule, advance or retire by echelons.

In order to avoid loss while changing position, it is advisable to limber-up without the enemy observing it; this can frequently be done by previously running back the guns.

11. *The Attack.*

In considering the attack, a distinction in principle must be made between an *accidental encounter* and an *attack on an enemy who has already deployed.*

In the case of an *accidental encounter,* which develops from the column of march against an enemy who is himself still forming line, the advanced guard should secure time and space for the deployment of the main body. This task falls in an especial degree to the field artillery. The better this arm succeeds in carrying on the action at first without the aid of any considerable force of infantry, the better will it secure freedom of decision to the commander of the troops.

For the purpose of carrying out the attack, it is of the greatest importance that the enemy's artillery shall be kept in check from the very first. *Quickness in movement and in ranging may create a superiority, which the foe will find it difficult to equalise.*

This task will be easier if our deployment is already further advanced than that of the enemy. If, on the contrary, the enemy is beforehand with us in this, and is already partly in position, the *decisive* artillery fighting, so far as is compatible with the task of securing the deployment of the main body, must be postponed. It should not be undertaken until we have approximately an equal number of guns in readiness for action.

The attack on a *fully developed,* and perhaps even *prepared, defensive position* requires that the deployment shall in essentials be completed before beginning the action, and the main mass of the artillery must, at all events, be on the spot.

A concerted attack can be expected to succeed only when the efforts made to attain the necessary superiority of fire are themselves successful; this applies first to the artillery fire. To this end every battery must be brought up into position.

The difficulty of getting over level ground which is commanded by the fire of the enemy may oblige us to make use of darkness in order to get near him. We should usually in such a case get forward on the preceding day to the boundary of the enemy's zone of fire, bring up the batteries into a selected, and if possible prepared, position, and commence the struggle as soon as there is sufficient light.

The distance from the enemy at which the *first fire-position* should be selected depends upon the intentions of the commander, the conditions of the action and the character of the country. In the case where it is impossible to silence the enemy's artillery from the first position, we must advance to within an effective range.

As soon as the enemy's artillery fire has been got under, and the *commander of the troops has determined which portion of the enemy's positions he will attack, a crushing artillery fire (as far as possible from encircling positions), must be concentrated on it,* whilst a part of the batteries fulfils the task of keeping in check the artillery of the enemy, especially so much of it as can bear upon the field of attack.

If, after the commencement of the infantry attack, batteries of the enemy enter, or return to, the struggle, and fire on our artillery, the main strength of fire must nevertheless continue to be devoted to the support of the infantry attack.

It is of advantage if the fire on the point of attack can be directed from a flank, since in that case a change of position will be unnecessary, so long as an accurate conduct of fire with reference to the following—distinguishing between friend and foe, the spread of the shell, the observation of the fire, &c. —may render any danger to our own troops impossible.

As soon as the attack draws near to the enemy's position, the ground in rear of the latter must be brought under fire, in order to hinder the advance of the enemy's reserves.

To *correctly assign the various "rôles"* with regard to this question, is one of the principal duties of the higher ranks of the artillery. To do so requires

a knowledge of the intentions of the commander of the troops, and also a clear judgment as to the state of the action.

It is advisable, in order to assist the *infantry attack*, to cause *its advance to be accompanied by single batteries up to the very closest and most effective range.* The strengthening, especially in "morale," which the attack will experience from such an accompaniment will fully outweigh the consequent losses of the artillery.

If the result be victorious, the *first pursuit with fire* will take place. In this the artillery in extended mass will assist. Part of the artillery must, as soon as the victory is recognised, hurry on to the front into the captured position, in order to aid the infantry in retaining it. This is one of those cases where the artillery commander must himself decide to make a change of position, even if no order to that effect has yet reached him.

As soon as the yielding enemy draws back beyond the most effective zone of fire, the *mass of the artillery* must follow at a rapid pace, must beat down the foe with fire, and must not allow him either to halt or re-form.

If the infantry attack fails, the artillery, especially those of them who are farthest to the front, must receive the retiring infantry and beat back the pursuit of the enemy.

12. *The Defence.*

In most cases the field artillery will be ordered at first to *take up a preparatory position*, even though the fire-position be artificially strengthened. In this manner only can it be made certain that the artillery will place itself opposite to the correct front of the direction of the attack, and will not be obliged early to change its position. The enemy will thus also be best prevented from obtaining an insight into our plans and intentions before the opening of the battle.

As soon as the general direction of the enemy's attack is recognised (and, if possible, before he has brought up his batteries), the fire-position will be taken up.

A personal inspection beforehand of the position, an improvement of the communications within it, and a knowledge of the various ranges (especially those of the foreseen artillery position of the enemy), are advantages which the defender must not neglect.

When preparing positions, the fullest use is to be made of *earthworks to cover the guns and detachments.* If there be sufficient time, the field of fire must be improved by cutting down hedges, trees, &c.; it is also advisable to construct screens, in order to render the observation of fire difficult to the enemy. It is of the greatest importance that very large supplies of ammunition should be placed in readiness in the immediate neighbourhood of the guns.

The commander of the troops will, as a rule, order the first shot to be fired. A premature opening of fire at too long a range and on small bodies of the enemy, should be avoided, since the enemy will thus easily obtain an insight into our position.

As a rule the action will commence by a combat with the *artillery of the attack*, and the *whole of the artillery should generally be brought into action*, in order to endeavour to obtain a superiority over the assailant.

The struggle with the enemy's artillery should continue until his *infantry advances to the attack.* After that, the artillery (if necessary abandoning their cover for the purpose) must take the infantry as their target, without paying any attention to the fire of the enemy's guns. If it be possible to do so, the hostile batteries should be occupied at the same time, but the *combat with the infantry attack will always be distinctly the main point.*

If, before the commencement of the infantry attack, the enemy's artillery

appears to be getting so much the upper hand that a continuation of the artillery duel promises no good result, the batteries may, by the order of the commander of the troops, be drawn back temporarily out of the reach of the enemy's fire. But as soon as he pushes on to the decisive attack, the artillery must, even without any special order, move up every gun at once into action against the enemy's infantry only, paying no attention whatever to the artillery fire of the foe.

If nevertheless the attack succeeds, a part of the artillery must hinder the advance of the enemy's batteries into the captured position, while another part concentrates its fire on such of his infantry as have forced their way in, in order, in combination with the reserves, to drive him back from the position which he has occupied. This is one of the phases of battle in which a *steadfast endurance up to the last moment* is required, and it *is then in the highest degree honourable if this be carried to the length of losing the guns.*

13. *The Pursuit.*

When after the success of the main attack the batteries have got up into the enemy's position, the field artillery must be at once specially employed, *with an utter disregard of consequences, in reaping the fruits of the victory in the pursuit.* It is peculiarly suited for this purpose, since it combines rapidity of movement with power of fire.

The first commencement of the pursuit is a general advance of the victors, which should be continued as long as their strength will in any way permit. During this above all things the *whole of the artillery must be brought into, and be kept in, action.* It must as far as possible *go in to the most effective range from the enemy.* It must hinder by the fire of masses any new taking up of a position by the enemy, and must beat down with fire such of the retiring columns as are still in order. This may be done even at the longest ranges, and directions will often be given to take the more distant fractions as the target, since demoralization there most easily sets in.

We must frequently give up all idea of preserving the cohesion of units. A rapid advance is the only thing necessary, and all means are permitted to facilitate it. The order with regard to individual changes of position can no longer be adhered to; upon this point the decision of the commanders, even down to the battery commander, will rule.

Flanking fire will be particularly effective. Horse artillery in combination with cavalry is specially suited for pressing upon a line of retreat.

14. *The Retreat.*

If an action has to be broken off, or if the result of a combat be unfavourable, the artillery can render special service, *if it resists the enemy without any regard to the consequent loss of guns,* and beats him down with its fire. In open country it alone can hold off the powerful fire-effect of a pursuing enemy so far from the columns of march (which are being formed under serious difficulties), that an ordinary retreat may generally be possible.

Positions in rear of defiles are especially favourable, as are also those from which a retirement can be made without the enemy perceiving it.

It is of especial importance to provide for the *security of ample supplies of ammunition,* for the complete reconnaissance of the roads of retreat, and for the discovery of several parallel roads by which to pass to a new fire-position.

Increased attention must be given to the flanks, since from them threatens the most dangerous influence on the retreat.

In the case where suitable flank positions can be found, immense assist-

ance can be given to the retreat from them, since they oblige the enemy to spend time in making changes of front. Horse artillery is especially suited for employment in this manner, owing to the long distances which must be traversed in order to make use of such flank positions.

15. *The Action of Horse Artillery in Combination with an Independent Force of Cavalry.*

The horse artillery which is attached to an independent force of cavalry is intended to increase the offensive strength of the cavalry, and moreover to supply it with the requisite power of fire for the defence.

The duties which devolve upon the horse artillery can only be fulfilled if it be sufficiently mobile to be able always to follow the cavalry, and if it be sufficiently skilled in fire to be able to obtain effect during the duration of their action, which is generally very short.

In the *reconnaissance duty* of cavalry the horse artillery will most frequently be of use in overcoming the resistance of the enemy at defiles or in occupied localities, or on the other hand in increasing the power of resistance of their own force at such places.

In a *combat of cavalry against cavalry* the artillery must move into posi tion as early as possible, in order to support first the deployment and then the charge of the cavalry. The fire-position will be selected as may best suit the task to be performed, and should be considerably to the flank of the advancing cavalry, since from such a position it will be possible to carry on the fire until immediately before the two forces come in contact, while the enemy can thus be prevented from turning the flank in question. A position which is secure against a direct attack is desirable, but in this matter also all considerations regarding cover must be subordinated to those connected with effect.

The *concentration on one spot* of all the batteries present is recommended, since numerous lines of fire will limit the movements of the cavalry, while, owing to the shortness of the time available, a concentration of fire can be obtained only by a concentration of position ; again, separate positions will necessitate more numerous precautions for the immediate safety of the artillery.

A change of position will almost always be rendered impossible by the rapid course of a cavalry combat.

If the enemy's cavalry be within effective range, the fire will be directed on them, the hostile artillery being entirely neglected, and the whole effect will as far as possible be concentrated upon the principal mass of the enemy.

If its own cavalry is not yet in a position to carry out its attack, the artillery may endeavour to draw off the fire of the enemy's artillery from the cavalry and on to itself.

As soon as the two masses of cavalry have met, and if no fresh force of the enemy's cavalry offers a favourable target as it comes up, the artillery will turn its fire on to the enemy's batteries. But nevertheless the cavalry fight must be continually watched, and every opportunity of assisting in its approaching decision must be seized. If the charge succeeds, the artillery will follow its victorious cavalry, in order to come into action as soon as the enemy rallies for fresh resistance, and in order to pursue him with fire.

If the charge is repulsed, the artillery commander must decide whether he ought to remain to the end in his fire-position, or whether he would do better to fall back into a position in which he may receive his cavalry. Owing to the short time available, it will be impossible to wait for orders on this point. Then, if ever, is the *moment for resolute action.*

COLONEL v. LÖBELL'S[1] ANNUAL REPORTS UPON THE CHANGES AND PROGRESS IN MILITARY MATTERS DURING 1888.

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THE present publication is the fifteenth issue of Colonel von Löbell's valuable military compilation, a work that has done more than any other published in or out of Germany for the student of contemporaneous military matters. As year follows year, the regular appearance of Colonel von Löbell's well-known green book is welcomed throughout the military world, as a trustworthy guide and record regarding every change of any importance, whether it be in the organization or the administration of armies, in their armament or equipment, or in the ever-varying phases of the tactics employed by the several arms. The detailed manner in which each of these subjects is treated, while enhancing in a high degree the intrinsic value of the work, has the single disadvantage that its bulk has hitherto stood in the way of a complete translation being made of it into our own language. It is the object of the present précis to remedy in some degree this disadvantage, by placing within reach of those who are debarred from consulting the original a short summary embracing those points that appear to be of particular interest. But in doing this we would again urge those Officers who are acquainted with the German language—and they are happily a constantly increasing number—not to content themselves with this necessarily imperfect abstract, but, on the contrary, to make a serious study of the work in the original.

The same arrangement has been followed in the latest volume as in previous years. The first part treats of the individual armies of Europe, and elsewhere, Asia, Africa, and America being each in some degree represented. This part forms the largest portion of the work, and occupies 300 pages. Of these, Germany monopolises 40, France 39, Italy 37, Russia 32, and Austria 24, the remainder being distributed over a number of States in all parts of the world. Amongst these may be noticed the Congo State, the armed forces of which are recorded as not without interest at a time when Colonial enterprise has so many sympathisers.

The second part deals with the several branches of the art of war. It embraces the tactics of infantry, cavalry, field artillery, and fortress warfare; the development of small arms and the situation of each of the European armies in regard to the re-armament of the infantry; the progress of military telegraphy between 1886 and 1888; and, lastly, a record is given of the military literature published during 1888.

The third and concluding part embraces ordinarily an account of the military operations conducted during the year. But on the present occasion there are none considered of sufficient importance to warrant special record here, though elsewhere the late operations at Sikkim and the Black Mountain Expedition are briefly referred to. The third part is therefore restricted this year to the obituary notices of General and other distinguished Officers,

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[1] Jahresberichte über die Veränderungen und Fortschritte im Militärwesen," 15 Jahrgang, 1888, herausgegeben von H. v. Löbell, Oberst z. Disp.—Berlin. Ernst Siegfried Mittler und Sohn. 1889. Pp. 596; size, 9·5″ × 6·5″ × 1″; weight 1 lb. 12 oz. Price 8s.

irrespective of their nationality, whose death was recorded during the year 1888.

Turning back now to a closer consideration of the first part, we find the foremost place is given, as is natural, to the German Army.

Germany.

New Organic Law.—It was the privilege of the Emperor William I, before his death, to affix his signature to the law of the 11th February, 1888, by which provision was made for a material increase to the armed forces of the Empire. The following brief abstracts show the more important of its provisions :—

Article I.—The first sentence of the fifty-ninth article of the constitution of the German Empire, dated the 16th April, 1871, contains the following provision :—Every German capable of bearing arms belongs to the standing army for a period of seven years, as a rule ; from the completion of his 20th year till the commencement of his 28th year—the first three years with the colours, the last four years in the reserve—the following five years to the 1st levy of the Landwehr, and then till the 31st March in that calendar year in which the 39th year of his age is completed, to the 2nd levy of the Landwehr.

Article II. First Section—Landwehr.—The Landwehr is divided into two levies. The obligation to service in the 1st levy of the Landwehr is of five years' duration. The entry into the 1st levy of the Landwehr follows upon the completion of the period of service in the standing army.

The obligation to service in the 2nd levy of the Landwehr lasts until the 31st March of that year in which the 39th year of age is completed.

Article II. Second Section—Ersatz Reserve.—The Ersatz Reserve serves to complete the standing army on mobilization, and to form the units of the Ersatz formations.

Each year so many men are to be allotted to it that the first requirements for the mobilization of the army will be met by seven yearly classes. In the first place, those individuals are to be allotted to it who have been found qualified for military service, but are surplus to the required quota for the colours, through having drawn high numbers.

The further requirements are to be provided from those fit and liable to service who have been exempted from duty with the colours for family reasons, those who have been found conditionally fit and exempted for minor physical defects, and those exempted for temporary unfitness, but who are likely to become efficient.

The Ersatz Reserve men can be called up once yearly to report themselves at the Recruiting Boards that are assembled in the spring. In time of peace they are liable to be called out for drill three times during their service : on the first occasion for a period of ten weeks, on the second for six weeks, and on the third for four weeks. The numbers to be called up to the first drill are fixed in the Estimates. The period of service in the Ersatz Reserve lasts twelve years, dating from the 1st October in the year in which the men become liable to military service. On the expiration of this period the Ersatz reservists who have been trained are passed to the 2nd levy of the Landwehr, and the remainder to the 1st levy of the Landsturm. The division of the Ersatz Reserve in two classes, which has hitherto prevailed, is abolished, and the whole of the men formerly attached to the 2nd class are in future to form part of the 1st levy of the Landsturm.

Fourth Section—Landsturm.—The duty of the Landsturm, in the event of war, is to undertake the defence of the Empire ; in cases of extraordinary emergency it can be drawn on to complete the army and navy. It comprises

all men liable to service from the completion of their 17th year up to 45 years of age who belong neither to the army nor the navy. The 1st levy is composed of those liable up to the 31st of March of that year in which they complete their 39th year. The remainder belong to the 2nd levy, which includes those who have completed their term in the army and Landwehr, and who continue in it until they attain the age of 45. The Landsturm is called up by Imperial decree, but in the event of sudden emergency, this may be done by Generals Commanding, by Governors, and Commandants of fortresses. So far as the military circumstances allow, the men are called out by yearly classes, beginning with the youngest.

Training and Manœuvres.—The new infantry drill-book was issued to the troops on the 1st September, 1888, and was made applicable to the whole of the infantry, including the Jäger and Schützen battalions. On the 15th October, 1890, the Generals Commanding army corps and the Chief of the Staff are to submit their reports to the Emperor upon the experience of the new drill regulations.

New musketry regulations have been issued applicable to the cavalry and the train.

Prizes for good shooting have been instituted for Officers and non-commissioned officers. For the former the prize is a sword, for the latter a watch, one of each being given in each army corps. All Captains and Lieutenants in garrison at the time fixed for the firing have to take part in the competition.

For the manœuvres in the autumn of 1888, the Guard Corps and the 3rd Army Corps were detailed for manœuvres before the Emperor, consisting of a grand parade and corps manœuvres against a marked enemy—each army corps separately—and then three days' manœuvres one against the other. Each of these army corps formed also a cavalry division of six regiments, with two horse artillery batteries for special cavalry manœuvres; but these joined their respective army corps during the period of the Emperor's manœuvres. The rest of the army corps followed the course of autumn manœuvres laid down in the Regulations for Field Duties. In seven of them cavalry long distance rides were practised. A pontoon exercise took place between Thorn and Graudenz, and a siege exercise at the latter fortress, each lasting for fourteen days.

Training of Reserves and Landwehr.—The number of men who had left the colours called up for drill in connection with the manœuvres during 1888 was as follows:—

	Men.
From the Reserve—	
Infantry of the 1st, 2nd, 5th and 6th Corps	61,500
Balloon detachment	40
From the Reserve and Landwehr—	
Infantry of the 4th, 7th to 11th, 14th and 15th Corps	40,700
Jägers and rifles	2,800
Field artillery	7,500
Garrison artillery	3,800
Pioneers	2,300
Railway regiment	400
Train	4,683
Total Prussian corps	123,723
And of the Bavarian corps	22,184
Grand total Army Reserve and Landwehr	145,907

The duration of the drills was twelve days, excepting in the case of the balloon detachment, who were up for twenty-eight days.

The number called up from the Ersatz Reserve was :—

	Men.
For a first drill of 10 weeks................	12,000
„ second drill of 6 weeks	10,700
„ third drill of 4 weeks................	10,250
Total Prussian corps	32,950
And of the Bavarian corps	4,810
Grand total of Ersatz reserve	37,760

The general total, therefore, of the Army Reserve, Landwehr, and Ersatz Reserve called up for instruction during the year 1888–89 was 183,667 men.

Belgium.

The Meuse Defences.—A first credit of 8 millions of francs was taken in 1887 for the construction of fortified bridge-heads on the Meuse. A further credit of 12 millions was taken for the same purpose, besides 800,000 francs for the purchase of ground for a military road between the gorges of the forts. The total expenditure amounts to 33 millions for the forts, 20 millions for their armament and cupola towers, and 900,000 francs for the ground, making a total of 54 millions of francs.

The forts will be constructed according to two different types, each of which will, in a certain sense, be an ideal one. They will embody all the improvements realized both in the science of artillery and construction. The building of these forts has been entrusted to a firm, chiefly composed of Frenchmen, under a contract for their completion by the 31st December, 1890.

Military Establishments.—The zeal of Belgium in improving in every possible way the instruction of her small army is worthy both of notice and of imitation. Notwithstanding the large sums devoted to extraordinary credits for the important works of defence that have been undertaken, money has not been grudged for the enlargement of the artillery practice and experiment ground at Brasschaet, for which purpose a credit of 750,000 francs has been taken. The Infantry School of Musketry has also been reorganized with a view to the instruction being extended, so as to embrace fire tactics under service conditions.

Manœuvres also have not been neglected, two infantry Divisions, with other arms attached in proportion, having taken part in them, and occupied the two last days united as an army corps in the attack of a position marked by troops from the garrison of Antwerp. A cavalry Division, with two batteries attached, was also engaged in manœuvres for fourteen days.

At least once in every year all the mounted troops are exercised in entraining.

Mobilization.—During the discussion of the Budget for 1889, the Minister of War stated the number of men necessary for the defence of the country to be as noted below. He added that these numbers were actually available :—

	Men.
Field Army, consisting of 2 army corps and 2 independent cavalry divisions	70,000
Antwerp (including the mobile troops)	30,000
Termonde	4,000
Diest	4,000
Lüttich (including the mobile troops)	8,900
Namur („ „ „)	5,000
Total force	121,900

In connection with the efficiency of this force, the deficiency in the number of Officers required is a matter for serious consideration. As many as 300 Officers are required to complete the war strength of the Army, and no less than 900 for the Reserve, which on paper numbers 30,000 men. An attempt was made to provide for these from Officers who had left the Service, and from non-commissioned officers; but this has not proved successful. Neither has, so far, another scheme, by which a new creation, to be termed "volontaires agréés," were instituted. These are enrolled as corporals, and, after an examination, become candidates for Officers of the Reserve. After six months' good service, and undergoing another examination, they are nominated to be non-commissioned officers—in which rank they serve two years before being nominated Officers of Reserve, if considered fitted for their position. They are then dismissed, being liable to be called up in time of war for the whole period of their engagement, and in peace-time for a month's training each year.

The institution is evidently a partial imitation of the German one-year volunteers, but the same excellent results are not to be expected from it, seeing that service in Belgium is not universal. It offers consequently no inducement to the high class of men who in Germany avail themselves of the opportunity offered them to avoid serving for the full legal period. The advantages offered, in short, are not very obvious, and a satisfactory solution of the difficulty existing in regard to Officers for the Reserve in Belgium cannot be expected to result from the course adopted.

Bulgaria and East Roumelia.

The development of the armed forces in this Principality continues, and with the new year the infantry underwent a material reorganization. Whereas it consisted previously of 12 regiments of 4 battalions each, the new organization is to be in 24 regiments of 3 battalions, which entails an increase of no less than 12 regimental staffs and 24 new battalions. A proposal was also made for the increase of the cavalry and artillery; but this was not approved by the Sobranje.

Denmark.

The chief interest continues to be the construction of the works designed for the defence of Copenhagen and its neighbourhood, for the continuation of which a further extraordinary credit was granted. During the year 1888 rapid progress was made with the construction and armament of these works, the condition of which is shown in the following summary.

1*st. Works completed.*—As regards the sea defences, the two coast batteries at Charlottenlund and Kastrup, regarding which the particulars were given in the Reports for 1886–87, have now been provided with their armament.

As regards the land defences, the works begun in 1886 and 1887, with the

object of preparing an inundation on the north and north-west fronts, are completed. An inundation, completely satisfactory from a military point of view, can now be created at short notice extending from Fresund up to the western part of the Utterslevmoor. This inundation is strenthened : partly on the right flank by the disposition of the Christiansholm battery, with the polygonal front appertaining to it, partly by four smaller flanking batteries lying behind the inundation, of which the two in Ordrupskrat are casemated, whereas the two batteries before Gjentofte, each have four 9 c.m. guns, are provided with bomb-proof magazines, and have guns on the open rampart.

The two batteries at Thinghoi and Vangede, which cover the centre of the position, are finished, and were very shortly to be provided with the armour-protected quick-firing guns destined for them.

2nd. *Works continued.*—The fort of Garderhoi, commenced in 1886, was so far proceeded with that the whole of the casemate buildings were ready. Early in the spring of 1889, the armament, which is to be composed exclusively of armour-protected guns, was to be commenced by the fixing of a Gruson tower for two long 15 c.m. guns. It is estimated that in the course of the year the fort will be sufficiently completed to receive its entire armament, as soon as it has been decided what this shall consist of.

The fort of Gammelmoorgaard, begun in 1887, had its glacis laid out, the necessary excavations prepared for the most important casemate buildings, and the works of drainage and communication completed. By the end of the year the earthworks will be practically finished, and the masonry work can be proceeded with.

3rd. *New Works.*—These may be arranged in two groups : one includes works undertaken on the north and north-west fronts for the elaboration of the system of works already in existence. The other comprises entirely new works on the west front.

The former includes the construction of a new provisional battery on the Thinghoi plateau. The armament of this battery is to be four heavy and two light fortress guns mounted on the open rampart ; and it is to be furnished with a bomb-proof magazine. The works were so far advanced by the close of 1888 that the masonry was completed, and the whole battery should have been finished during the spring of 1889. The battery is in conformity with the adjoining batteries of Thinghoi and Vangede in being furnished with a broad, shallow, planted ditch.

The Christiansholms battery also, the work on which was stopped provisionally in the summer of 1888, is now to be prepared, and armed with three short 15 c.m. guns with armoured carriages on Schumann's system. The foundations for these were to be ready in the spring of 1889. Besides these three guns, it is to be furnished with two 47 m.m. quick-firing guns, the whole being protected with armour. Quick-firing and machine guns with armoured protection are also to be provided for the batteries of Thinghoi and Vangede.

The new works on the west front consist in a connected enceinte from the west side of Utterslevmoor to Kjöge Bay. With this work will be completed the undertaking having for its object to provide Copenhagen with a connected protection against an attack from the Seeland side. The enceinte has a length of 14 kilometres, and consists of 23 fronts, of which 9 are to be on the polygonal system, and the 14 others on the Danish system. The character of the latter fronts is the result of a remodelling continued during many years, of a front construction suited to the Danish conditions, and by which is secured a complete polygonal flanking by means of bomb-proof caponniers in combination with a flanking defence from the rampart, as in the bastion fortification. A wet ditch, 20 metres broad, constitutes the

passive defence, and is exposed to a powerful and complete flanking fire, provided for as indicated above.

The works which could not be seriously commenced earlier than July, 1888, were pushed on with the greatest energy. Unless their progress should be interrupted, it is estimated that they should be finished by the autumn of 1889. The extent of the undertaking can be judged of by the amount of earth to be dealt with, viz., 2½ million square metres.

Egypt.

The total strength is given as follows :—

471 Officers, of whom 54 are British, 417 natives.
518 officials.
8,642 non-commissioned officers and men.

The British Officers were distributed in the following manner :—

24 belong to the several battalions, &c.
4 form the staff on the frontier.
3 form the staff at Suakin.
8 belong to the Medical Service.
15 occupy special positions as head of departments or in the Ministry of War.

Exclusive of the staffs, the Egyptian Army was composed as follows :—

	Officers.	Men.
11 battalions of infantry (4 black, 7 Fellah battalions)	204	6,897
6 batteries of artillery	26	606
2½ squadrons of cavalry	19	465
2 camel corps	8	196
Total (24 British, 233 native Officers)	257	8,164

These, together with the increase of 2,080 men recommended by the Sirdar, would place the total strength at 10,244 combattants.

France.

The Army budget for 1889 shows an increase of 15 millions of francs for the ordinary expenditure over 1888.

The sums placed at the disposal of the War Minister, as extraordinary credits, for the purpose of obtaining war material of all kinds, for the construction of new works and for strengthening of works previously in existence, reached a sum of over 770 millions of francs. Already more than 2¼ milliards had been devoted to the same objects; but the end of this extraordinary expenditure seems as far off as ever.

During the course of 1888 the peace strength of the army was increased, both by the creation of new formations and by the increase of the effective strength of these units. The new formations amounted to 1 cavalry regiment, 24 rifle companies, 12 companies of Algerian light infantry, and 16 batteries. By an alteration in the organization of the infantry regiments, 145 new battalions were added to the Territorial Army.

The increase of the rifle companies was introduced by a law dated the 24th December, 1888, which provided that all the rifle battalions should, in due course, be increased from 4 to 6 companies, according as might be

required by the exigencies of service and as money was available. In the meantime, the 12 battalions belonging to the 14th and 15th army corps districts, specially destined for operations in a mountainous country, were to be raised to the increased strength forthwith.

The actual increase in effectives over the existing establishments was as follows :—

1 to the battalion staff.
1 Lieutenant, to be in charge of the vehicles and mules.
1 sergeant } to look after these.
1 corporal }
1 corporal as shoeing-smith.
1 corporal as sick attendant.
3 privates as artificers and clerks.
7 to lead mules and driver.
2 draught horses.
8 mules (2 to each company).
1 Lieutenant or Sub-Lieutenant.
17 privates.
8 mules.

A law dated the 28th December, 1888, provided for the alteration in the artillery. The 12 new mountain batteries to be raised were to be attached, 6 to the divisional artillery regiment of the 14th artillery brigade, and 6 to that of the 15th brigade.

The strength of these batteries was fixed at the following :—

Establishment of a Mountain Battery.

1 Captain with 2 horses.
1 1st Lieutenant with 1 horse.
2 2nd Lieutenants or Sub-Lieutenants with 2 horses.
1 Adjutant with 1 horse.
1 maréchaux des logis chef with 1 horse.
1 fourier with 1 horse.
7 bombardiers.
1 bombardier as 1st shoeing-smith.
5 fire-workers.
4 carpenters and smiths.
2 assistant shoeing-smiths.
2 saddlers.
2 trumpeters.
122 gunners with 26 draught horses and 60 mules.

Total strength of the battery 160 Officers and men, with 34 horses and 60 mules.

Another law of the same date as that last referred to dealt with the subordination in time of war of the entire railway system to military authority.

The Minister of War makes the dispositions respecting all the lines lying within the country which are not situated within the sphere of operations. This control passes to the Commanders of the several armies in the case of those lines that lie within the sphere of operations. The Minister of War decides the time when this is to come into force in respect to each army and each line.

Amongst others the following are placed under the orders of the Generals commanding armies :—

1. Sections of railway workmen already organized and formed in time of peace by the railway companies and State lines.

2. Formation of railway troops.

The Administration of each line is to be represented at all times at the Ministry of War by an agent, who in peace time has, by the direction of the Minister, to make all the preparations for the transport of troops in war, and in war time to see that this is safely carried out. The Administration may further be called upon, even in peace, to attach an agent to the General who would in time of war command the army destined to operate in the district in which the line is situated. This official will have the same responsibility towards the General referred to as the agent previously mentioned has to the Minister.

A superior Military Railway Committee is to be formed already in time of peace.

On the motion of the War Minister, representatives of the Ministries of War, Marine, and Public Works, and of the large railway companies, are nominated by decree as members. Its sphere of action is to extend to the discussion of all matters concerning the employment of railways for war purposes.

In connection with the decree, regulations have been published regarding the following details (in the *Bulletin Officiel*, partie régl. No. 69) :—

1. Regarding the organization of the different branches which have to arrange for the transport ordered, and superintend its execution. At the head of each branch is an Officer and a technical agent of the railway company.

2. Regarding the organization of the railway workmen and their being called up in peace, the period of which is not to exceed 21 days.

3. Regarding the composition and sphere of action of the superior Military Railway Committee.

4. Regarding the organization and duty of the Etappen officials.

Recruiting.—The details of the number of recruits and their allotment to the several arms are to be found in the *Bulletin Officiel*, No. 43).

The total number of recruits, exclusive of non-effectives and those for the Navy, amounted to 152,228. The following were called up and assigned as noted :—

From the 1887 Class, 133,999, of whom	128,999	1st portion.
	5,000	2nd portion.
1886 (put back)	12,973	1st portion.
1885 „	4,009	„
	1,247	2nd portion.

Reserve.—Half of each of the yearly classes, 1879 and 1881, were called up for drill.

During the autumn manœuvres, between the 20th August and the 16th September, only the reservists belonging to the 3rd and 16th Army Corps were called out. Those of the other army corps were only drilled for 13 days, during the month of October, which was a departure from the practice in previous years. The infantry, zouaves, rifles, fortress artillery, and engineers (only those employed with the railway companies), as well as the non-commissioned officers of the infantry reserve detailed as drivers of the small-arm ammunition wagons in war, were up from the 1st to the 13th of October. The drivers referred to received their training with the Field Artillery. The rest of the Engineer reservists were up from the 3rd to the 15th October. Those of the Field Artillery were up in two series, each of 13 days' duration.

The untrained reservists of all arms indifferently were up for four weeks' training, from the 1st to the 28th October. The only exception was in the case of the cavalry reservists, of whom only those were called up who would be turned over to the Field Artillery in the event of mobilization. All those men who had not served actively before their transfer to the reserve were regarded as untrained. The calling up of the reservists took place by means of public proclamation.

In the course of the year the reservists of the Train and of the Administrative services were called up for different periods, each of four weeks, by means of notices personally addressed.

During the period between the 1st July and the 31st December the several yearly classes still under obligation to serve were distributed in the following manner :—

With the active army	the classes from	1887 to 1883
„ reserve to the active army	„ „	1882 to 1879
„ territorial army	„ „	1878 to 1874
„ reserve to the territorial army	„ „	1873 to 1868

Remounts.—For 1889 the number of horses was fixed at 111,664 (exclusive of those belonging to the gendarmerie).

Of these, 13,543 were Officers' horses ; 784 for the schools, and 97,335 troop horses; being 4,838 more than in 1888.

14,148 remounts were to be bought ; the prices were fixed at the following rates :—

	Officers' horses. francs.	Troop horses. francs.
Horses for cuirassier regiments	1,400	1,160
„ dragoon regiments, the general staff, artillery and train	1,260	1,036
„ light cavalry	1,140	910
„ infantry	1,000	—

The total sum taken in the Estimates for 1889 on account of remounts was 14,370,520 francs, being an increase of 1¼ million francs over that for 1888.

The Remount depôts at Angers, Mérignac, Arles, and Favernay were converted into dépôts de transition, and attached to the Remount depôts at Fontenay, Agen, Macon, and Villers. The buying committees previously existing at the first-named depôts were done away with.

War Matériel.—The provision of a large number of new field, fortress, coast, and siege guns is contemplated for 1889 ; about 180 millions were taken in the Estimates for extraordinary expenditure.

The following leading principles for guidance in the construction and armament of fortifications are stated to have been laid down by the superior Council of War :—

1. The detached forts and small independent works are to be provided with all the means made available by the present state of technical science for offering the most obstinate resistance ; for with them the fortified works themselves, and not their garrison, will form the main point of the defence.

2. Less money is to be spent over the larger works than hitherto ; for their chief strength lies in the action of large garrisons, in the extensive development of the fronts of fire, and in the skilful utilization of the ground.

3. To abandon a number of the smaller fortresses.

The Engineer Committee have further determined upon the type of

armoured towers, and how these can be adapted to the fortresses and detached forts.

In the course of the year continuous alterations were made in the fortresses and forts, and were directed chiefly to the restoration of the covering of the bomb-proof shelters, and to placing new armour, in view of the increased powers for destruction of siege artillery.

Layers of "beton" were used for the bomb-proof covering (*L'Avenir militaire*, No. 1286, 1314, 1316, 1320). A short description of the French fortresses, with four maps, is to be found in the *Guide-poche de nos forts et places fortes*, Paris, 1888. Lévy et Cie.

A further completion of the frontier fortifications is contemplated by the construction of new works and the strengthening of existing ones. For this purpose the following sums are provided in the budget for 1889:—

	francs.
For the fortifications of the eastern frontier	62,533,000
" " " south-eastern frontier	168,000,000
" " " northern frontier.......	5,000,000

A further sum of 25 millions was asked for by the Minister of War for the construction of forts, intermediate works, and railways at Paris. The Budget Committee did not report in favour of this expenditure, on the grounds that the sum was too small for the purposes for which it was required, and added their opinion that there was no pressing necessity at the moment for the construction of new works. The Minister of War stated that he would be under the necessity of renewing the demand later on.

Means of Communication.—The entire railway system, which at the end of 1878 comprised 23,401 kilometres, amounted at the end of 1887 to 34,210 kilometres, showing an increase of 11,000 kilometres in the 9 years, an increase in excess of that constructed by any other state. Strategical considerations have regulated principally the construction of the new lines. Regulations have been published for the instruction of the railway regiment, the formation of which was planned in 1888, but not carried out. The instruction is divided into two parts, the one dealing with the military, the other with the technical instruction. The former is to be conducted under the regulations for infantry as far as company drill; battalion formation is only to be adopted on parade. The technical instruction is to be carried out by the railway schools attached to the regiment, and by means of practical exercises. The Colonel of the regiment superintends, and is the head of the school; a battalion commander of the engineers acts as director, and the necessary teaching staff and civil instructors are attached. The curriculum comprises the French language, mathematics, physical sciences, geography, history, engineering duties, and the construction and working of railways.

The practical exercises take place in the first instances by companies, later by battalions, and then by the entire regiment. They extend over all the duties required to be performed by railway troops in war. A number of Officers and men are trained in the duties of working the line, of the workshops, and of telegraphy, as well as in driving locomotives. On the Government line, between Orléans and Chartres, two small detachments of railway troops have been employed since the spring. Each detachment consists of 1 Captain, 2 Lieutenants, 11 non-commissioned officers, and 48 corporals and privates. One detachment provides, in combination with the civilian officials, for the work at six stations and on the trains; the other is only there for the purpose of being instructed. The Lieutenants act as station-masters: the non-commissioned officers as assistants and telegraphists; the corporals as engine drivers, and the privates as guards, stokers, pointsmen, &c.

Military Telegraphs. By a decree of the 10th November, 1888, amending that of the 23rd July, 1884, regarding the organization of military telegraphs, the whole of the personnel of this service is to be employed in time of war with the army in the Directions, the sections of the 1st and 2nd lines, the telegraph park, and in the territorial service. The Minister of War decides on the places at which the several formations are to be mobilized, and the day when the mobilization must be completed. From the commencement of this, the officials and agents of military telegraphy form an integral portion of the army, and are subject to its laws and regulations. They enjoy according to their rank all the rights, honours and distinctions accorded to persons in the territorial army. A General, to be nominated by the Minister of War, is charged with the inspection annually of all branches of the military telegraph service.

The departments of War and Finance make the necessary arrangements for furnishing and keeping up the matériel.

The chief of the staff and the telegraph official attached to the general command for this purpose, in each region, are to make the necessary arrangements in time of peace for the rapid mobilization of the directions, parks, and sections, as well as for the organization of the territorial service.

Army Estimates.—The ordinary estimates for 1889 were fixed at 550,652,402 francs, being an increase of nearly 14 millions on the previous year.

As regards the extraordinary expenditure, the original scheme, which involved the spending of over 2¼ milliards of francs in replacing war matériel was completed at the end of 1887. But it did not follow that the extra expenditure was at an end ; on the contrary, the demands made in 1888 for purposes of national defence amounted to another milliard. The greater portion of this, viz., 770,731,000 francs, were voted in December last by an overwhelming majority of the Chamber. Of this sum 228,335,000 francs have already been spent, 138,554,360 francs are allotted for 1889, and the rest is to be spread over the five following years.

The total establishments of the army for 1889 were fixed at 541,365 Officers and men. But as in this number 42,314 men are included and borne as temporary absent, the average effective strength would amount to 499,051 Officers and men.

Taking the higher number, the troops proper, including the departmental services, amount to 501,826 Officers and men, distributed as follows :—

	Officers.	Men, all ranks.
Infantry	10,899	304,521
Cavalry	3,273	71,270
Artillery	2,518	70,586
Engineers	388	10,581
Train	396	11,400
Administrative branches	—	16,043

As compared with the establishments in 1888, those for 1889 show an increase of 16,369 men and 4,838 horses, and a decrease of 579 Officers (530 infrantry and 49 gendarmerie) and 136 gendarmes.

Ministry of War.—By a decree dated the 12th May, 1888, the Superior Council of War was reorganized for the fifth time since its establishment in 1872. At the same time the Committee of Defence was dissolved, on the grounds that as the new fortifications had been executed, it was no longer required. As formerly organized, the Council of War was only assembled at the pleasure of the War Minister, and often for a year at a time it was never

called together. In future the War Minister must assemble it at least once a month to discuss questions connected with defence, mobilization, the construction of strategic lines of railway, the general organization of the army, and the armament and defence of the coasts. The Council consists of 12 members, of whom four belong to it by reason of the positions they fill, and eight are appointed by presidential decree. The former are the Minister of War, who acts also as president, the Chief of the General Staff, to whom the duties of reporter are entrusted, and the presidents of the Artillery and Engineer Committees. The President of the Republic is empowered to call the Council together and take the Chair, in which case the Minister president and the Minister of Marine attend. The sub-chief of the General Staff charged with the work concerning military operations acts as Secretary. Besides these, the Directors of Sections at the War Department attend when the subjects to be discussed are connected with the branches for which they are responsible. In the event of questions as to the construction or abandonment of fortified places, or coast defences, having to be decided, the General Commanding the region affected, the Inspectors General of Artillery and Engineers or in the case of coast works, the Chief of the Staff to the Minister of Marine, the Inspector-General of the Marine Artillery, and the sea prefect of the arrondissement concerned.

The members appointed by decree were the Governor of Paris and seven divisional Generals. Of these latter it is believed four would in the event of war be appointed to the command of armies. To avoid these commands being assumed by Officers unacquainted with the state of the several army corps that would come under their orders, a decree of May, 1888, provides for their being informed by letters of service which army corps would form their respective armies. And though they cannot exercise command over these until their actual formation on mobilization, they are held responsible for the performance of very important duties in connection with them during peace. These are to look into everything connected with mobilization, war matériel, the distribution of the troops, the position of fortifications, and the means of transport, so far as they are connected with the sphere occupied by the several corps destined to compose the respective armies. These Generals are also to be employed in time of peace with special missions by order of the Minister of War, and to preside at conferences at which the corps commanders are assembled for the discussion of questions affecting several army corps. Special instructions issued by the Minister of War regulate in each individual case the relations between the corps commanders and the members of the Superior Council; the latter are to avoid any interference in internal arrangements, and they are to assume the control of the manœuvres of army corps operating in concert.

A new organization was also given to the consultative Committees. Their functions are to be limited to subjects of a purely technical nature, and not to be extended to those concerning administration, personnel, law, and strategy. The consultative Committees of the General Staff, of the several arms, of the sanitary service, and of the Intendance are to be termed Technical Committees, and are to limit their discussions to the questions referred to them by the Minister of War, concerning organization and training, and the changes to be made in these. The number of members of such a Committee is to be nine, of which seven must belong to the arm or branch of the service concerned. The Minister of War nominates the presidents, for the period of one year, and the members, who must belong to the troops stationed within the area of the Military Government of Paris or the neighbouring regions.

Re-armament of the Infantry.—During 1888 nearly the whole of the infantry was provided with the new repeating rifle on the Lebel system. In November

as many as 2,200 of these rifles were turned out daily, of which 1,200 by the St. Etienne small-arm factory, 600 by that at Chatellerault, and 400 at Lille. The whole of the infantry belonging to the territorial army are to be furnished with it also during the present year.

Train des Équipages.—In the Manual for General Staff Officers it is laid down that on mobilization each squadron of the train forms three new companies, which take the numbers 2, 4, and 6. The six companies are then formed into nineteen detachments. The 1st and 3rd companies, attached to the two infantry divisions, furnish three detachments, each for the horsing of the field post and treasury wagons, the ambulance wagons, and provision columns of the division. The 2nd company also furnishes three detachments for the ambulance wagons, and the first half of the corps provision column, and provides the personnel for the mobile remount depôt.

The 4th company furnishes, in five detachments, the horses, &c., for the ambulance of the cavalry brigade, for the field post and treasury wagons of the army corps, the second half of the provision column of the army corps, the clothing column, and the telegraph section of the first line.

The 5th company forms four detachments: three for the ambulances and drivers for the mules; the fourth for the six field hospitals.

The 6th company only provides for the field bakery column; the remainder stays with the immobile army corps. The strength of the Train squadron of a mobile army corps has for its cadre 21 Officers, 80 non-commissioned officers, 92 corporals, 16 trumpeters.

Officering the Territorial Army.—During the year 1888 the number of Officers was materially increased, especially in the infantry. Over 900 new appointments were made in the rank of captain, partly by appointing retired captains, partly by the promotion of lieutenants; 700 sub-lieutenants were also appointed from those who had been one-year volunteers and non-commissioned officers. A number of superior Officers who had served in the Marines were also transferred to the Territorial Army. The increase was necessitated by the contemplated addition of a fourth battalion to territorial regiments. It is further contemplated to form fifth and sixth battalions in the event of war, to be called supplementary battalions.

Following the instructions of the 1st January, 1879, the Ersatz districts for the individual battalions of the infantry territorial regiments were assigned to the arrondisements and cantons within the sub-divisions (8) into which each region is divided (the 15th has 9). This arrangement has now been abandoned, and it has been ordered that the whole of the battalions of a regiment shall be recruited from the entire sub-division district, the troops belonging to the other arms throughout the region. No change has taken place in the points for mobilization.

It has been stated by the press that, in the event of mobilization only, the youngest class with the territorial army, viz., those 30 years of age, would be taken for the active army; that the 1st and 2nd battalions of territorial infantry regiments would be sent into the field, and be composed exclusively of men of from 31 to 34 years of age, and that the remaining battalions would be formed from the reserve of the territorial army.

One half of the whole number of the two classes 1876 and 1877 of the territorial army were called out for training during a period of thirteen days. The infantry were armed with the new magazine rifle, and two battalions took part in the national celebration of the 14th July.

Greece.

The strength of the Greek Army, as fixed for the estimates for 1888, was 26,340 men. It is divided between three General commands, the headquarters of which are stationed at Athens, Missolonghi, and Larissa.

The infantry consists of 10 line regiments of 3 battalions of 4 companies, 139 strong, and of 8 rifle battalions of 4 companies, 132 strong; but of these latter 6 of the battalions only are kept complete, the remaining 2 being only cadres.

Of cavalry there are 3 regiments of 4 squadrons, each 129 strong, with 101 horses. The artillery is composed of 3 regiments, of which the 1st and 2nd have each 4 mountain batteries; the 3rd 3 mountain batteries, 2 field and 1 mortar battery. Total 14 batteries each of 6 guns; the mountain batteries have a strength of 122, the field batteries of 132.

There is one regiment of Engineers of 2 battalions of 4 and 5 companies respectively, the 5th being a railway company; the strength of each company is 119.

There is one company only of Train, and a double company of the Sanitary service.

Universal service was introduced in 1887, the obligation lasting from the completion of the 21st to that of the 51st year.

This period is distributed as follows:—

In the Standing Army	2 years.
„ Reserve to the Army	8 „
„ Landwehr	8 „
(in the cavalry 10 years)	
„ Reserve to the Landwehr	10 „
(in the cavalry 8 years)	

The number of recruits to be enrolled each year is fixed by the War Ministry, and the required number chosen by lot. The remainder of the year's contingent go to the Ersatz Reserve, paying a fixed sum to free them from having to come up again the following year to take their chance for the active army.

The reserve to the army are to be called up for forty days' training during the 4th and 8th year of their service. The Ersatz reserve receive three months' training, and are during the rest of their term liable to be called up by the War Minister to supply the waste of the active army.

The law prescribes no drill for the Landwehr or its reserve. It lays down only that the former is to be called up in the event of war, the latter in case of invasion.

Italy.

The period of service in the active army is now uniformly fixed at three years, with the exception only of men in the cavalry, who serve four years. The year's contingent was fixed at 82,000 men for the army; but only 77,120 actually joined the colours. These were distributed 46,577 to the infantry, 6,438 to the cavalry, 12,879 to the artillery, 2,852 to the engineers.

The enrolment of volunteers was provided for as follows:—

One-Year Volunteers.—1. Each regiment to enrol 4 per company, squadron, or battery, to be counted in the establishment of the regiment.

2. Every military hospital Direction 4, of whom 1 to be an apothecary.

3. Every district having the headquarters of a General command 2 as Ersatz Officers for the commissariat or pay corps.

Ordinary Volunteers (*for* 1889).—Every regiment of infantry, bersaglieri, artillery, and cavalry 10; each engineer regiment 10; Alpine troops no limit.

Remounts.—On the 1st July, 1888, there were 8,014 horses on the remount depôts. Of this number 4,200 were bought last year in Italy as foals. During the year 3,000 horses had been supplied by the depôts. They now provide the whole of the cavalry, one-third of the artillery, and the Officers of all ranks

who are entitled to them. Owing to the division or doubling of the regiments of field artillery, a great number of horses have had to be purchased.

A new law for the requisition of horses provided that in case of war all quadrupeds (thus including mules) suited to military purposes may be taken at their estimated value. Those not actually taken remain at the disposition of the State. In each parish a list is drawn up of all the owners of horses or mules, and on the basis of these Committees are to be appointed annually to inspect and value the animals, and they are lettered according to the order in which they would be called up on mobilization. By a report made to the Chamber it appears that the first requirement, amounting to 120,000 horses, could be easily obtained, and the entire number required could be got in Italy alone.

Magazine Rifle.—The converted Vetterli rifle is still the arm in use ; and provision has been made for the further conversion of 350,000 rifles from the original pattern into magazine arms during 1889. Trials with an arm of reduced bore have been carried on notwithstanding.

The number of rounds carried by troops armed with the magazine rifle are as follows :—

6 packets of 8 cartridges in the havresack........	48 rounds.
3 „ 8 „ „ pouch	24 „
6 magazines of 4 cartridges in the pocket	24 „
Total	96 „

Troops armed with the single loader carry 8 rounds less.

Strength of Armed Forces.—On the 1st June, 1888, the following was the strength :—

Permanent Army—	
Officers in active service, on half-pay, &c.	14,309
Ersatz Officers	4,110
Non-commissioned officers with the colours	16,215
„ „ on unlimited furlough..............	6,468
Corporals with the colours	42,774
„ on unlimited furlough	70,344
Privates with the colours	177,714
„ on unlimited furlough, 1st category	290,756
„ „ „ 2nd „ (trained)........	175,884
„ „ „ 3rd „ (untrained)...	616,479
Total Permanent Army	1,405,053

Officers' horses	8,680
Troop horses	35,846
Total................	44,526

Mobile Militia—	
Officers	533
Ersatz Officers	2,741
Non-commissioned officers	6,521
Corporals	30,519
Privates, 1st category..	163,431
„ 2nd „ (trained)..	62,465
„ 3rd „ (untrained)..	122,636
Total Mobile Militia	388,846

Territorial Militia—	
Officers	5,512
Non-commissioned officers	11,677
Corporals	54,072
Trained privates	575,496
Untrained privates	695,982
Total Territorial Militia	1,342,739
Grand Total	3,136,638

(Of whom 1,435,097 untrained).

It is to be noted that all are returned as "trained" who have been called up for even short periods of drill.

Training of Reserves.

The infantry and bersaglieri of the 1st category of the yearly class 1860, were called up for 10 days, the Alpine troops for 23 days, 21,400 men. These took part in the manœuvres.

The 1st Category Class, 1862, of all arms, except cavalry, for 28 days. The Alpine troops with those of the 1860 class. The total number of these was 37,100, and they also took part in the manœuvres.

The 2nd Category Class, 1867, 17,400, men for 45 days; for such of them as had gone through a year's course with the National Rifle Association the period of instruction was reduced to 20 days. Including men of the mobile and territorial militias, the total number called up during 1888 for instruction was 131,000, showing an increase of a quarter over the number in 1887. For 1889 it will be still greater, in order that all the men not with the colours may be instructed with as little delay as possible in the use of the magazine rifle.

Reorganization of the Artillery.—The changes prescribed by the law of 1887, detailed in the Reports for that year, have been gradually carried out. The general inspection, inspections, and artillery commands contemplated by it were called into existence by a decree of the 7th June, 1888, which defined the scope of their respective jurisdictions and duties.

The Inspector-General is placed directly under the Minister of War; he superintends the technical service of the artillery, controls the studies and experiments relating to the artillery service, the matériel, the employment of the arm in war, and the armament of fortresses. He makes proposals of a general nature, *i.e.*, such as it is beyond his own sphere to decide. Under the orders of the Minister of War he inspects in all branches of his service.

The Inspectors have similar duties to perform within their several jurisdictions. Of the two Inspectors of field artillery one deals with the field artillery in the district occupied by the 1st to the 5th army corps, the horse artillery, and the mountain artillery regiments; the other deals with the field artillery of the 6th to the 12th army corps. They communicate with the Minister of War through the Inspector-General.

The Officers at the heads of the several artillery commands have the same authority and duties as the former artillery territorial commanders; that is, as a brigade commander in everything relating to discipline, duties, and training of artillery. Personally they are, together with their Officers, subordinated to the General commanding the district in which they are situated. For the rest they are directly responsible to the Minister of War, and communicate with him on all points concerning 1st, the technical and administrative part of the duties of the Territorial Directions and Artillery Establish-

ments ; 2nd, the civilian official personnel with the regiments, Directions, and Establishments. The four field artillery commands are established in Milan, Piacenza, Bologna, and Rome, the two fortress artillery commands in Turin and Rome.

The doubling of the field artillery regiments was prepared for in 1887 by the creation of four new batteries per regiment, which then had 14 batteries each. On the 1st October, 1888, the light (7-cm.) batteries which had previously in peace 6 guns each were reduced to 4 guns. On the 31st October two new heavy (9-cm.) batteries were formed per regiment, and from the following day the separation of each of the regiments, now 16 batteries strong, into two regiments, took effect. Of the 24 regiments thus formed 12 are divisional artillery, and are armed exclusively with heavy guns. 12 are corps artillery, and have in each of their two brigades of 4 batteries two armed with light, and two with heavy guns. Whereas the peace strength hitherto of batteries having 4 guns, was 100 men, and 54 horses, the new batteries have only 90 men, and in the case of heavy batteries 45 horses, of light 42. On mobilization the batteries are all to be made up to 6 guns, in place of 8 as previously. The divisional artillery regiments have each one train company, the corps artillery regiments two companies. In war, besides the artillery brigade and regimental commanders, there is to be a commanding Officer of artillery with every infantry and cavalry division.

Creation of Engineer Inspections.—On the 1st July, 1888, a General Inspection and Inspections were created for the Engineers. On the same date the Artillery and Engineer Committee was dissolved.

The Inspector-General is directly under the Minister of War ; he superintends the technical duties of the Engineers, and controls the studies, duties, and buildings connected with the Engineer service. He makes proposals regarding questions of a general nature, and he inspects all branches of the service under the orders of the Minister of War.

The Inspectors perform similar duties within their own spheres.

Mobile Militia Training.—The 1st Category of the infantry and bersaglieri of the Classes 1856, '57, and '58, belonging to 15 districts, amounting to 17,000 men, were called up for 10 days' drill. The Officers were up for 12 days. The men were formed into 21 battalions and 20 bersaglieri companies ; the battalions were commanded by Officers of the line, the companies by Captains and Lieutenants, for the most part drawn from the active army. The result of the training was regarded as satisfactory ; but the Officers belonging to the Mobile Militia, for the most part taken from one-year volunteers, left much to be desired as regards their efficiency.

Organization.—The new organization prescribed in 1877 was detailed in the Reports for that year. The following modifications have been made in giving effect to it :—

There are now 48 infantry regiments (in place of 44).
12 brigades of field artillery (in place of 13).
13 train companies (in place of 14).
34 fortress artillery companies (in place of 36).

The several units of the Mobile Militia have the same strength and composition as those corresponding to them in the permanent army, except that they do not have bands. In the reorganization an approach has been made to the territorial system by allocating the regiments to districts.

Territorial Militia Training.—The 1st and 2nd Categories of the infantry, Classes 1852, '53, '54, and '55, and the 3rd Category, Classes 1861 to 1866, of 23 parishes, in all about 15,000 men, were called up. They were formed in 31 battalions at the large garrisons, and drilled for 10 days, exclusively by

Officers of the Territorial Militia, with one exception. The period was pronounced too short for any solid results to be obtained, and the same insufficiency was observable in the efficiency of the Officers as was the case with the Mobile Militia. The 1st and 2nd Categories of the Artillery, Classes 1852, '53, and '54, of 21 districts, numbering about 3,000 men, were up for 15 days. The 3rd Category, Class 1867, about 18,000, for the same period. The Territorial Militia forms now an integral part of the army, and it is to be armed with the converted Vetterli rifle. The period of drill is fixed at 30 days every four years—which may be spread over these years.

Sanitary Service.—The "Red Cross" Society in Italy is organized under the Minister of War for services with the army, and can provide the following assistance:—

	Beds.
13 hospital trains with beds for 200 sick or wounded	2,600
4 hospitals with 200 beds	800
12 " 50 "	600
Total	4,000

To facilitate the work of the Society, the Minister of War has sanctioned the exemption from other service in peace and on mobilization of men belonging to the Territorial Militia, excepting those of the artillery, engineers, sanitary and supply services, who are enrolled as members of the Society.

Montenegro.

Since 1883 the Montenegrin forces have been composed of a standing army and the war levy. The dimensions of the former are very limited; it consists of the guard 300 strong, a portion of which is mounted, and three garrison battalions 490 each; total, 1,770 men. The war levy consists of 45 battalions, for which arms are available; and 300 artillerymen trained by Russians, with 24 Krupp guns (7·5-cm.). The total strength is estimated variously at from 24,000 to 35,000 men capable of bearing and trained to arms from earliest youth.

Austria-Hungary.

The Army law of 1868 fixed the strength of the army, in the event of war, for a period of ten years. It was renewed for a like period with certain modifications in 1878, and consequently came on again last year for a further renewal. The occasion was taken advantage of to introduce material alterations, which were met with considerable opposition in the Chambers at Vienna and Pesth, as well as in the country generally. The original basis on which the number of the annual contingent of recruits was that they should be sufficient to secure to the State an armed force of 800,000 men (including navy) in first line; this number was 95,474. The object aimed at has been so far satisfied by this arrangement that on paper the 800,000 have been fully maintained. But it has been alleged, very truly, that a paper strength is not the effective strength, and that to deduce this from it, 8 per cent. must be deducted, in this case 64,000. To obtain, therefore, an effective strength of 800,000, the paper strength must certainly not be less than 864,000, to maintain which necessitates the yearly contingent being increased to 103,100; and this is provided for by the new law.

A further increase is made in the case of the Ersatz Reserve, which in the army as well as in both Landwehrs is fixed at 20 per cent. of the annual contingent. In accordance with this the number of recruits to be annually enrolled for the several branches of the armed forces is as follows:—

	Men.
For the Army	103,100
„ Ersatz reserve to the Army	20,620
„ Austrian Landwehr	12,000
„ Ersatz reserve to Landwehr	2,400
„ Hungarian Landwehr	12,500
„ Ersatz reserve to the Hungarian Landwehr	2,500
Total	153,120

These numbers are calculated to provide not only for a field army of 1,200,000 men, but further for maintaining it, during a war of long duration, at that strength by means of the Ersatz reservists.

A material point in the new law is the alteration in the age at which those drawn to serve in the active army come up, from 20 to 21 years of age. The necessity for this was stated to be the defective growth and stamina of the recruits called up from some portions of the Austrian dominions. The obligations to service now, therefore, begins with the 1st January in that year in which the 21st year of age is completed. The term of service is 3 years with the colours, and 7 years in the reserve to the active army, 10 years in the Ersatz Reserve, 2 years in the Landwehr and its Ersatz Reserve, and lastly in the Landsturm up to the completion of the 42nd year. Those who are enrolled direct in the Landwehr without previously having served in the regular army or Ersatz Reserve belong to it and its reserve for 12 years. The obligation to serve in the Landsturm in the case of Officers unemployed or who have left the army, lasts until the age of 60.

An important addition has been made to the regulations regarding one-year volunteers. It is upon this class that the reserves are in great part dependent for Officers in the lower ranks. On the conclusion of the twelve months' service every one-year volunteer has to present himself for examination, with a view to qualifying for appointment as an Officer of reserve. But it was found that these young men placed no particular value upon qualifying for the position, and a large proportion failed to do so. In order to put a stop to this unsatisfactory state of things, a new regulation has been adopted by which those one-year volunteers who fail to pass the examination at the end of their term of service will render themselves liable to serve for a second year.

War Matériel.—By the end of February, 1889, the small-arm factory at Steyrer had turned out 230,000 of the new small-bore (8 m.m.) magazine rifle, and gave a daily output of 860. As many as fourteen infantry divisions had been armed with the new pattern and furnished with the new ammunition for it, and also for the most part with the new pattern two-wheeled company ammunition carts. The infantry regiments and rifle battalions which had been armed with the new rifle had the whole of their reservists up for a special 7 days' drill, for the purpose of exercising them in the use of the magazine arm. With a view to improving the shooting of the army, so as to ensure the best possible result from the use of the magazine rifle in war, the allowance of ammunition for target practice was raised in the infantry from 110 to 150 rounds per man, which is the number previously allowed in rifle regiments.

The introduction of a fuze that will burn for an increased length of time has the double advantage, that the field artillery will have an increased range for shrapnel fire, and be able to employ indirect fire to a greater extent.

In the entrenched camp of Przemyszl several provisional works were strengthened, some converted into permanent ones and armed anew. In the fortress of Cracow a large artillery arsenal was commenced, and in the

Southern Tyrol the reconstruction of existing and the creation of new works, commenced the preceding year, were continued. The land defences of Pola, commenced in 1887, will be completed in 1889.

Communications.—In the course of 1888 several branches, the construction of which was recommended by the railway section of the General Staff, in connection with the important strategic line Kaschau-Oderberger, were undertaken. The single lines on the Czerencs-Legenye Mihály line of the Hungarian North-Eastern Railway, and on the Legenye Mihály-Mezö Laborcz line of the Hungarian-Gallician line, were doubled. This was also done on the Hatvan-Miskolcz-Czerencs line of the Hungarian State Railway. In Hungary also a new main line was laid from Sunja to New-Gradiska 77·8 kilometres in length, and a line, Vlarapaso-Tepla-Trencsin-Teplitz (46·5), besides several minor and local lines.

Modifications in Organization.—The peace establishments for 1889 was fixed at 18,960 Officers, 276,400 other ranks, and 51,460 horses.

With the object of ensuring a more rapid and effective mobilization, several modifications, some of considerable importance, have been introduced into the previously existing organization, these are to the following effect :—

1st. The creation during peace of certain formations previously postponed until the period of mobilization. Such were the creation of five heavy battery divisions on a reduced peace establishment and of three train squadrons for five and three Landwehr divisions respectively ; the formation of the staffs for the three most important cavalry division commands ; and the establishment of a telegraph Ersatz cadre to the railway and telegraph regiment.

2nd. The strengthening of the existing formations, which were considered too weak for the requirements of a mobilization. Thus the number of senior Officers was increased with the infantry, rifles, railway, train, and sanitary troops, so as to have an Officer available to command the new formations to be called into existence on mobilization. An increase in the strength of eight railway companies.

A further increase to the army has been effected by making supernumerary 640 Officers and 1,500 non-commissioned Officers and soldiers detached to schools and offices from the troops. The total increase for the year amounts to 1,341 Officers, 3,136 men, and 407 men, without including 2,050 men and the same number of horses of the cavalry kept supernumerary to the ordinary establishments, with a view to meeting the increased requirements of the cavalry on mobilization through the formation of staff detachments.

Siege Batteries.—At the close of the manœuvres in 1888, a provisional organization was introduced by the formation of a group of mobile siege batteries to be a mean between field and fortress artillery. The guns of the field artillery are often too light to carry out effectively the attack against hasty field entrenchments. The heavy guns of the siege train are not easily made available against hastily constructed works, and they are not required for the purpose. Guns of position of 12 cm. calibre and 15 cm. mortars are amply sufficient, and are more easily moved. So as to have them available with the various columns operating at a distance from the siege park of an operating army, they are to be organized in groups and rendered mobile. A trial with this object was made at the Vienna arsenal by the formation of one battery of guns and two of mortars into a "Group of siege batteries." The gun battery was composed of four 12-cm. short steel-bronze guns, the mortar batteries each of four 15-cm. steel-bronze siege mortars. The group, therefore, comprised 12 guns, with 82 wagons, 534 men, and 409 horses. The experiments carried out gave very satisfactory results, and it was decided to make these groups a permanent formation for the artillery. Five groups are to be formed : two in Vienna, and one each for Budapest, Cracow, and Przemysl. They will be separated entirely from the siege park, and attached

to the operating armies, where they will be placed directly under the army, army corps, or divisional-commander.

Russia.

The law regarding universal service of 1874 received an important alteration by a decree of the 26th June, 1888, which was stated by the Russian press to be intended to meet the new provisions of the German Army law.

Obligation to service begins with the 21st year of age. The recruits are selected in the autumn of the year in which they complete their 20th year. The duration of service in the standing army is 18 years, of which 5 years with the colours and 13 in the reserve. The period with the colours is shortened in the case of the educated classes according to a scale which varies with the standard of education, and is different according as the individuals have been raised, in the ordinary manner, by lot, or are volunteers. This is shown by the following table :—

		With the colours.	In the reserve.
Men Raised by Lot.			
1st standard of education	Leaving certificates from the several educational establishments	2	16
2nd „ „		3	15
3rd „ „		4	14
Volunteers.			
1st standard of education	Certificates from educational establishments of the 1st and 2nd classes	1	12
2nd „ „	Special examination..........	2	12

In the case of the populations beyond the Caucasus and of the foreign populations of the Kuban and Terek territories, the service is 3 years with the colours and 15 in the reserve.

The reservists are obliged to attend two trainings, each of six weeks duration.

The Reichswehr consists of the entire population capable of bearing arms who do not belong to the standing army, from their 21st year till they complete 43 years. They are divided into two levies. The first levy serves to complete and strengthen the standing army as well as to form Reichswehr cormations, and includes men belonging to the following categories until the fompletion of their 43rd year :—

1st. Those who have completed their army service.

2nd. Those who are liable but are not taken for the regular army, provided they are fit for active service and are not the only support of their families. The four youngest yearly classes are under military control, and can be called up for two trainings of six weeks' duration.

The second levy serves exclusively to form the units of the Reichswehr troops, and is composed of those individuals who have been exempted from

service in peace time on account of their being the only support of their families, and of those who have not been found fitted for active service.

Certain classes of professional men are given great concessions in regard to the obligation to serve. Those in holy orders belonging to any Christian persuasion, and the trained psalm-readers of the orthodox faith at the clerical academies, &c., are entirely exempted. Doctors, veterinary surgeons, apothecaries, teachers, artists trained abroad at the expense of the state, can only claim exemption during peace.

Claims on account of family, property, and civil education are taken into consideration, exemption during peace being granted or temporary postponement of service, according to the circumstances.

The changes made in the new law, particularly those which have for their effect to shorten the service with the colours and to lengthen that with both the reserve and the Reiehswehr, should be of great advantage from the military point of view. If, as is alleged, the machinery for thoroughly training the men in the shorter period (virtually four instead of five years for the majority) is in existence, the gain is evident, and will also be a great boon to the people. By prolonging the length of service in the reserve by three years, the number of trained men available for the field armies will be increased by about 637,500 men. Of more importance than the prolongation of the obligation to serve in the Reichswehr from the age of 40 to that of 43, is the provision that the four youngest yearly classes belonging to it shall be subject to military control. Though not in name, this virtually provides a valuable Ersatz reserve, previously wanting in the Russian organization.

Establishment of Pigeon Posts.—As an experiment, military pigeon posts are to be tried for a period of three years, under the control of the Engineer Department. Their object is to maintain communication with the fortresses in the event of investment. The post-stations are divided into four classes, according to the number of directions in which communication has to be maintained ; 250 pigeons is the number allotted to each line. The 1st class stations are under a Lieutenant-Colonel, the rest under other Officers. Those situated in fortresses are subordinate to the commandants, others to the chiefs of the military district staffs. A special breeding depôt is to be established at Brest-Litovsk. The stations at which the experiment is to be made are stated to be the following :—

Brest-Litovsk, 1st class

Line to Novogeorgievsk	200	versts	1,000 pigeons.
„ Warsaw	170	„	
„ Ivangorod	130	„	
„ Luninez (near Pinsk)	200	„	

Warsaw, 2nd class—

Line to Novogeorgievsk	25	versts	750 pigeons.
„ Brest-Litovsk	170	„	
„ Ivangorod	85	„	

Novogeorgievsk, 3rd class—

Line to Brest-Litovsk	200	versts	500 pigeons.
„ Warsaw	25	„	

Ivangorod, 3rd class—

Line to Brest-Litovsk	130	versts	500 pigeons.
„ Warsaw	85	„	

Luninez, 4th class—

Line to Brest Litovsk..............200 verst—250 pigeons.

Communications.—The lines opened for traffic in 1888 were the following :—

Trans-Caspian as far as Samarcand.
Romny—Krementschug.
Samara—Ufa.
Rshef—Vjasma.
Jassinowataja—Kalmius (Donez-Becken).
Samara—Volga bank.

The following lines are in course of construction :—

Kasatin—Uman—Schpola.
Wapnjarka to a station on the line Kasatin—Uman.
Riga—Valk—Pskoa.
Valk—Dorpat.
Ufa—Slatoust.

A new arrangement has been approved of for goods wagons to facilitate their employment for the transport of troops. It allows of their being disposed in two tiers, and has the advantage of giving room for them to lie down at night.

Infantry-Reserve-Battalion Cadres.—These cadre formations have received an increase in the number of their officers, and three battalions have been expanded into regiments of two battalions each. This in itself is of no great importance; but if, as has been rumoured, this expansion were to be extended to the reserve battalions generally, it would mean an increase to the army of 116 battalions.

Increase of Rifle Battalions.—The twenty single rifle battalions that existed previously have been converted into twenty rifle regiments of two battalions each. It is stated that a further development is contemplated, by which a 3rd and 4th battalion would be added, and that eventually separate brigades will be formed from these troops.

Train.—At last a special formation of train troops has been adopted by Russia. Five train cadre battalions have been formed, of which No. 3 has two companies and the rest four. The companies are divided into 5 subdivisions, and are numbered throughout from 1 to 18. Each subdivision serves as the basis of a war transport. The establishment of a battalion of four companies in peace is 15 Officers, &c., 399 men, 40 two-wheeled carts with 80 horses. Each battalion has on charge the necessary vehicles, harness, and equipment for the expanded formations in war.

On mobilization each company is expanded to form a war battalion (Nos. 1 to 18), each furnishing 5 war transports (90). The commanders in peace of the battalions become heads of the army transport, the company commanders are appointed to command the war battalions. Each wagon transport is divided into two subdivisions of four sections, with a total of 183 two-wheeled carts. The amount of provisions to be ordinarily carried by each of these wagon transports consists of a four days' supply of biscuit and groats, and an eight to ten days' supply of salt, or tea and sugar for 10,000 men, as well as a three days' supply of oats for 1,600 horses. The requirements of the transport column itself is also provided for.

Supply of Ammunition.—Flying artillery parks are attached to the divisions of the mobilized army in the following proportion : 4 (two with S.A., two with gun ammunition) to each infantry division.

Those for S.A. ammunition carry 413,568 rounds and 2,880 revolver cartridges.

Those for gun ammunition contain :—

492 shell, 540 shrapnel, and 48 case for heavy guns.
912 „ 960 „ 48 „ light „

Movable artillery parks are attached—2 to each reserve division of the 1st category ; 1 to each of the 2nd category, and 1 each army corps. One of these parks contains, if for S.A. ammunition, 343,296 rounds and 5,760 revolver cartridges ; if for gun ammunition :—

246 shells, 270 shrapnel, 24 case for heavy guns.
608 „ 640 „ 32 „ light „

The total number of rounds available per rifle is 196·8 distributed as follows : on the soldier's person in the pouches and pack, 84 ; in the S.A.A. carts, 48 ; in the flying artillery parks, 53·3 ; in the movable parks, 11·5. The number of rounds carried per heavy gun of the army corps is 259·5, viz., 117·2 shells, 129·6 shrapnel and 12·7 case, and per light gun, 268·2, viz., 126·4 shells, 133·9 shrapnel, and 7·9 case.

Local parks would be formed according to circumstances, in addition to the mobile ones referred to above.

Training of the Troops.—Apart from the ordinary exercises by units and manœuvres by mixed bodies of troops, the employment of the several arms in exercises of a special nature is of interest, as showing the earnest desire to train the soldier in a practical manner for war. Such are, for infantry, the practice of night attacks, the attack and defence of entrenched positions, and the "penetrating attack," in which the troops launched to the attack are not permitted to halt until they have penetrated the enemy's ranks. The greatest attention continues to be given to an improved rifle instruction. With the cavalry, distance rides, and swimming rivers continue to be practised, and with this arm also "penetrating attacks" against firing infantry and guns. The artillery have been practised as in 1887 in firing on bivouacs, and in one of these practises the limbers were left behind and the ammunition brought along on the horses of the detachment.

Training of Reserve.—The number called up was 128,379, belonging to the infantry, field and fortress artillery of European Russia and the Caucasus ; the duration of the training was from 21 to 26 days. The classes called up were those of 1883, whose service with the colours had been shortened, and those of 1878, who had served from 3 to 5 years with the colours.

The most important part of the reserve exercises was the trial mobilization of the 31st reserve infantry division and the 51st reserve artillery brigade. For this purpose four companies of the reserve infantry battalions, Nos. 54, 61, 67, 68, and the third battery of the 4th reserve artillery brigade, were brought together, and from these were formed four regiments of four battalions and four batteries of eight guns, without horsed S.A.A. wagons. In order to complete these formations to a war strength, 49 Officers and 15,678 men were called up from the reserve for 26 days. As the number of reserve Officers was not sufficient, the requirement was completed by detached line Officers. The horses were obtained under the special law on the subject from the inhabitants of the district concerned. The men joined between the 21st and 25th August at the place of mobilization, and were placed under canvas till the 5th September, when the mobilized units were forwarded, fully equipped, by rail to the manœuvre ground. The result of the experiment was stated to have been most satisfactory, but it must be remembered that it was partial only in its nature, and it had long been known that it was to take place.

Turkey.

Recruiting.—The result in 1888 of the new recruiting law of 1886 was to furnish a contingent of 40,000 men (1st portion: 1st training class), which allowed of the two reserve classes, 1883, 1884, being sent down. Besides this number, about 23,000 men (1st portion: 2nd training class) were called up for training for a period extending from five to nine months. This training of the men belonging to the Tertib sani (2nd training class) is a clear gain to the armed forces of Turkey, and it is said to have given very satisfactory results. Not including these men, the peace strength of the army was about 185,000 men.

Defensive Works.—The new works on the Dardanelles, Yeni-Kali, and the island of Tenedos were frequently inspected by the President of the Engineer Department. Those situated on the island of Tenedos, at the entrance to the Dardanelles, were finished, and were shortly to receive their complete armament. A scheme was put forward for the construction of some works in the Vilajets of Salonika, Monastir, and Cossowo.

Armament.—During 1888 the final delivery under the contract concluded with Krupp in 1885 for field guns was made, and the Turkish artillery now has 1,000 of these guns (7·5 and 8·7-cm.). A further consignment of 12 coast guns, namely—2 of 35·5 cm. (80-ton guns) and 10 of 24 cm.—was delivered in February, 1889, together with a supply of ammunition for them.

Communications.—The most important point to be noticed is the granting of a concession to a German firm for the construction of a railway in Asia Minor, from Eski Scheir to Angora, a distance of 400 kilometres. As long ago as 1872 a scheme was worked out for the construction of a railway system in Asia Minor. The question has since been frequently discussed, and nine years ago the first step was taken towards carrying it out by the construction of the European portion, from Constantinople (Haidar Pacha) to Ismidt (92 kilometres). But no company with capital came forward to undertake the further portion of the scheme until 1888, when English, French, and Germans competed for the concession. A concession was also granted for a local line from Jaffa to Jerusalem.

The beginning now made will assuredly lead to the extension of railways throughout Asia Minor in due course, and while the importance of this from the commercial point of view should be considerable, it will undoubtedly be of much greater moment from the strategic standpoint. By the construction of a system of railways the rich recruiting ground offered by Asia Minor will be opened up, and it will become practicable to bring the whole resources of the Turkish Empire to bear on an European theatre of war.

Infantry Tactics.

In Germany the series of new regulations, having for their object to bring the instruction of the army up to the level of the latest developments in arms and in the tactics resulting from the introduction of them, was crowned by the publication, on the 1st September, 1888, of the new infantry drill book.[1]

Comparisons between the new regulations and those they replaced have been published in many forms, as also in many languages. They show that the emendations and changes in the old regulations are very numerous, but beyond getting at this result the comparison is not of any great value. It will be sufficient to note here that the foundation on which the new regulations are based are, 1st, that the individual instruction of the recruits shall be

[1] For a summary of its contents see No. 148 of the Journal.

as thorough and complete as it is practicable to make it; and, 2ndly, that what is taught throughout shall be applicable to the battle-field. The enormous amount of experience gained during the war of 1870–71, the collation of which has become possible through the publication of numerous regimental histories, and the works of many able writers who took part in the campaign, has allowed of decisions being arrived at as to what formations and movements are absolutely impracticable under effective fire. All such have been either altogether omitted or reserved for use exclusively on formal parades, and the number so reserved has been reduced to a minimum. A reference to the summary already referred to in the note will show how completely this rule has been adhered to. The reasons for it are not far to seek. In the first place, with the shortened service, time is no longer available in which to teach men formations and movements which it is impracticable to use before the enemy without heavy losses being entailed. And, in the next place, experience shows that what soldiers have been taught in peace they will, in the excitement of the battle-field, naturally do; it is, therefore, of double importance to restrict the instruction to such points as will be required in war. One other very noticeable point is the absence from the new regulations of any normal formation for attack, and the absolute prohibition against any such being drawn up or practised.

In France, also, new regulations were issued for trial by the infantry, in May, 1888, but were found to be so impracticable that they were withdrawn. The spirit in which they were drawn up is evidenced by the fact that the five parts into which they were divided contained 766 pages, whereas the German Regulations contain 172.

The issue of new Musketry Regulations gave more satisfactory results. The number of rounds of ball ammunition to be fired yearly is, for the active army, 120; for reservists, 27; and for men of the territorial army, 20. The exercises are divided into individual firing, at which 88 rounds are fired at ranges up to 600 metres. The remainder, 32 rounds, are fired in six practices, in volleys, at 600, 800, and 1,000 metres; one practice being devoted to magazine volley firing (8 volleys in the minute); one practice at independent fire advancing from one position to another, from 600 to 500 metres; and one practice with rapid fire with the sight at 400 metres. In addition to this, 50 rounds are allotted to field firing, and are distributed as follows: two practices at unknown distances, under a non-commissioned officer; one practice in volley firing, under the commander of the sub-division; one practice as a company advancing to the attack from 800 to 200 metres; and one practice as a battalion advancing to the attack in the same way.

The 8th chapter, which deals with the rules for the control of fire, is the most important, and is based on the performances of the new Lebel magazine rifle. Fire control is carried out by units, which should not be larger than a half-company. The commanders of these regulate the beginning, the end, the interruption, and intensity of the fire, the object of which is to produce the greatest possible effect in the shortest possible time. Fire at long ranges seldom repays the expenditure of ammunition; when it is employed, a large number of rifles should be directed on the same object. The employment of fire is ruled by the consideration whether the engagement is of the nature of an attack, of a defensive action, or a rapid assault. In the attack, fire should be opened as late as possible, but then continued with the greatest possible energy and rapidity. As regards the application of the different kinds of fire, the battalion commander points out the object to be fired on, and, as far as possible, the portion of the enemy's line on which the fire is to be concentrated. The Captains regulate the application of the fire and the expenditure of ammunition, and point out the object if this has not been done by the battalion commander. Half-company commanders and non-commissioned

officers superintend the proper arrangement of the sights and the direction of the fire. Volleys are only to be fired by units not larger at the most than a half-company; rapid fire is only to be employed at decisive moments, and magazine fire only on the command of the Officers. The distances are divided into: short (up to 600 metres); medium (600 to 1,200 metres); long (over 1,200 metres). Individual fire is only to be employed up to 300 metres against skirmishers covered or lying down, to 450 metres against single horsemen, 600 metres against groups of four or more men. Concentrated fire is recommended against objects of the breadth of a group up to extended columns and lines from 800 to 2,000 metres, being dependent in a great degree upon conditions of weather. Officers and non-commissioned officers are at the medium and long distances to observe the effect of the fire, and regulate the sights accordingly; in exceptional cases, where opinions regarding the distance differ as much as 200 metres, the sights may be set at several distances. As regards the vulnerability of the several formations, it is stated that the company in line begins to feel the effect of fire at 1,800 metres; the half-company columns and company columns at 2,000 metres; men kneeling are almost as easy to hit as standing up.

The Italian infantry also received in 1888 new musketry regulations, as a result of the introduction of the magazine rifle. As in the cases of France and of Austria during the past year, this issue of the new arm has entailed a material increase in the quantity of ball ammunition allowed for practice.

Cavalry Tactics.

No material changes took place during 1888 in the views already generally accepted in regard to the manner of employing cavalry in war. In the matter of equipment, the days of the cuirass are at an end except as a parade dress; and its use has been discontinued by the German cavalry. The lance, which had fallen into disrepute, and been entirely set aside by some European armies, is coming into favour again, and it seems likely to be established in the high place it formerly held. The question of giving the cavalry a repeating carbine has been freely discussed; but in France alone it was decided to arm the cavalry regiments with one, namely with the Lebel repeating carbine (8 mm.).

In Germany increased importance was given to the use of the carbine by the publication of new Musketry Regulations for the Cavalry. In these it is pointed out that instruction in firing is one of the most important portions of the training of cavalry, and must be carried out in all its parts with the greatest care. Whereas formerly special prominence was given to the training of the cavalry soldier at short distances, it is now prescribed that he is to be equally carefully trained throughout the three classes, for it is at longer distances that fire will ordinarily be possible. In field firing the manner of delivering the fire is restricted to groups and subdivisions; individual firing finds no place. Firing by groups is employed principally at short distances up to 500 metres; by subdivisions at medium and long distances.

The practical value of a more thorough training of cavalry in the use of the carbine was evidenced by an advanced guard exercise carried out over the Hagenau practice ground. A squadron formed part of the body of mixed troops employed, and was utilized dismounted from time to time to direct carbine fire against targets representing an enemy. The results were not altogether satisfactory, and gave occasion for the General Commanding to point out that, though the employment of cavalry with their carbines dismounted would seldom occur, adequate training is indispensable if they are to avoid a check in such cases. The difficulties for the subdivision com-

manders in judging distances correctly in unknown and unexpected conditions, in quietly conducting the fire, and maintaining fire discipline, are clear; constant practice is, therefore, required.

In Russia, judging from the dispositions made for the manœuvres, the theory regarding the employment of masses of cavalry as mounted infantry appears to have continued to lose ground. Great stress was laid upon the importance of cavalry being employed in concert with, or in opposition to, infantry in every manœuvre in which infantry took part. Night manœuvres were practised, and it is thought in Russia that in future wars they will play an important part.

In France the tactical training of the cavalry is seriously interfered with by the number of recruits, due to the short periods of service (generally 3½ to 4 years), and by a number of the remounts being unfit for the field. Including volunteers, each regiment has from 260 to 290 recruits each year; and, judging from the manœuvres, when the Divisions were about 1,900 horses short, the regiments are still worse off in the matter of horses. In these days, when training under service conditions is acknowledged to be of so much importance, French cavalry is placed by these circumstances in a very disadvantageous position as compared with the German.

Field Artillery Tactics.

The issue provisionally of new Drill Regulations[1] for the Prussian Field Artillery in the spring of 1888 will no doubt be followed by the adoption generally of new regulations, the necessity for which has arisen through the changed conditions under which the arm is now employed in the field.

The principal tactical question under discussion has been the bearing on the employment and importance of field artillery fire, of the introduction of magazine arms. In an article in the German military review, "Mittheilungen über Gegenständes des Artillerie-und Geniewesens," this question is discussed by Captain Freiherr v. Stipsicz. He arrives at the conclusion that, seeing that it was already impracticable to attack a position held by infantry with ordinary single loaders without previous thorough preparation by artillery fire, the necessity for this will be enhanced in the case of the defenders being armed with repeaters. To ensure this thorough preparation, he urges :—

1st. The most extensive employment possible of the fire of artillery masses;

2nd. That sufficient time be allowed in which to bombard the place at which the assault is to be made;

3rd. The direction upon this and also on the reserves of a powerful fire;

4th. Immediate accompaniment of the attack, especially by those batteries that are masked by the infantry, up to 675 or 750 metres.

These principles for the employment of artillery must exercise an influence on the organization of the field artillery, for they will necessitate a strong corps artillery. The deductions drawn by the writer for the training of field artillery in peace are three :—

1st. The most important is its instruction in every phase of fire action; more attention must be paid to firing at long, even very long, ranges.

2nd. The training in firing by masses must be attended to much more than hitherto.

3rd. The great mobility and power of manœuvring of the artillery will form one of the most important factors in firing by masses.

With the exception of the increased importance given by the writer to

[1] For a summary of contents see No. 149 of the Journal.

practice at very long ranges, his views are no doubt practical and just. The necessity for a good and strong artillery to silence the fire of the enemy's guns, and to search out that portion to be attacked, and so increase the chances of success from the infantry attack, is still greater than it was before. He who remains the victor in the artillery engagement is apparently the victor in the battle.

Fortress Tactics.

The report on this subject is divided into two portions. The 1st treats of the defensive works undertaken by the several European States, the improvement of matériel, and the organization of fortress troops. The 2nd portion is reserved for the discussion of various questions relating to fortress warfare which have been raised in the press.

As being intimately connected with the defence of the frontier, the following comparison is drawn between the lines of railway available and projected at the disposal of Russia and Austria respectively. The former has six lines which lead to the Western frontier, of which the first stops a few miles short of it; these are :—

1. St. Petersburg—Warsaw—Czenstochow.
2. Moscow—Minsk—Brest-Litovsk—Kielce.
3. Kursk—Pinsk—Ivangorod.
4. Kursk—Kief—Lub.
5. Charkof—Balta—Proskurof.
6. Odessa—Schmierinka—Proskurof.

Under certain conditions the line Odessa—Kischenef—Jassy could also be utilized.

The projected lines are four, namely :—

1. Lodz—Sierad—Wilhelmsbrück or Sierad—Kalisch.
2. Kutno—Kolo—Sluzce.
3. Pinsk—Kowel.
4. Lublin—Zamosk—Tomazof or Lublin—Ostrovice;

the main directions of which lead also to the German or Gallician frontier.

Austria has the following lines :—

1. Prague—Olmütz—Prerau—Oderberg—Cracow—Stryi.
2. Josephstadt—Prerau—Odby—Cracow.
3. Brünn—Prerau—Oderberg.
4. Pressburg—Pesth—Chyrow—Lemberg.
5. Vienna—Sander—Chyrow—Stryi.
6. Kaschau—Tarnow.
7. Graz (Agram)—Pesth—Debreczin—Munkacz—Stryi.

These will not suffice in the future, particularly as on some portions of the system several lines run in common, and further strategical lines are in contemplation.

Italy also has not been idle in the matter of connecting her fortified places on the coast with the interior, for which purpose contracts have been concluded for the construction of the following lines :—

1. Velletri—Terracina.
2. Sparanise—Gaeta.
3. Avellino—Ponte S. Venere.
4. Genoa—Ovada—Asti.
5. Cernia—Piombino.
6. Cuneo—Saluzzo.

Besides these, the line Udine—Portogruaro is to be completed during the year, after the difficulties offered by the bridging of the Tagliamento have been overcome. Special attention is being paid to coast defence, as is evidenced by the construction on the island of Caprera of three forts, and on Maddalena of four forts, with good roads and landing places, arsenal, barracks, hospitals, and magazines. The two places are further to be connected by a bridge. The extensive works at Spezia are being continued, and several new forts have been designed. Large expenditure is also being incurred for the equipment of fortresses, construction of heavy guns, engineer matériel, and siege trains.

France and Russia have also turned their attention to coast defence—the former in connection with Toulon, Brest, and Cherbourg, the latter in the conversion of Libau into a fortified port at great expense. The importance of this port is due to the fact that at a time when the northern port is closed by the ice, Libau is open and available for the entry or egress of Russian vessels.

The works in progress in Belgium for the preservation of her neutrality, both on the Meuse line and the modifications in the fortified places of Antwerp, Termonde, and Diest, to meet the most modern ideas, have already been alluded to, and they should be completed in two or three years.

Switzerland, also, having in view the maintenance of her neutrality, has voted the necessary money for the construction of defensive works at Andermatt, on the St. Gothard.

At Bukarest, of the eighteen forts to be constructed to complete the system of defence, seven were completed during 1888, and three more commenced.

In Turkey the question of the land defences has at last been seriously taken up; an entrenched camp is to be formed at the lines of Tschataldja for 50,000 men, and the defences of Adrianople are to be reconstructed.

Amongst the improvements in matériel, perhaps the most important is the development of high explosives, and their adaptation for purposes of bombardment and mining. The Report, while referring to them and to the acknowledged difficulties in the way of their practical use in war, gives no details as to the experiments carried out in various countries, and especially in Austria. In one form and another the problem has been under consideration during the past ten years, and one important result has now been reached. Shells loaded with a high explosive substance have been fired with success, and practically without danger; but this has been under peace conditions. In war the difficulty of transport, and the fear lest atmospheric conditions, such as damp or heat, should set up chemical changes of a dangerous nature, must, in the present state of knowledge, at least limit, if it should not altogether prevent, their use.

The question of rapid communication in war continues to attract attention, and during the past year some interesting observations were made on the subject in France. From these it appears that 1 kilometre can be covered by a pigeon in 1 minute, by a hound in 2 minutes, by a bicycle or a mounted man at a gallop in 3 minutes, and by the latter at a trot in 4 minutes. The establishment of the pigeon post on an extensive scale in Russia has already been referred to. In connection with the operations about Massowa, the Italians have made practical use of the pigeon post with excellent results. Communication is not only regularly maintained between the outlying posts and the chief station at Massowa, but reconnoitring patrols take with them pigeons in baskets, to enable them to communicate intelligence rapidly back to the station from which they were sent out. If a pigeon arrives back without having a message attached, and with some of its tail feathers pulled out, it is an intimation that the patrol has been surprised.

It appears, also, that in Italy a way has been found of maintaining balloons

in the field, or before an invested fortress, for purposes of observation, without the encumbrance of a bulky train. Small balloons, suitable for one observer, have been constructed for the expeditionary corps in Africa, the necessary gas for their inflation being contained in an easily transported, small, steel cylinder. The entire transport per balloon consists of three vehicles.

The same difficulty, namely, the necessity for a bulky train, is encountered in the application of the electric light for the purposes of fortress warfare. Experiments made in Austria showed that with three wagons a powerful light can be obtained and maintained, capable of being rapidly moved. Both in Germany and in Spain experiments were made in night operations, both the ground and the object being lighted up by the electric light. In the case of the Spanish trials, it was found that in individual firing under peace conditions the hits were as 74 by day to 33 by night; but in field firing under service conditions the results were about equal. The German experiments showed that those men within the sphere of light made better practice than those without it.

Great attention has been, and continues to be, paid to the employment of quick-firing guns in fortress warfare. In Germany, experiments conducted at Krupp's factory with these guns, varying in calibre from 4 to 13 cm., of which the two heaviest, namely, the 10·5 and 13-cm. guns, appeared the most suitable for fortress warfare. The time occupied in firing one round was four and five seconds respectively. Italy has adopted the 12-cm. Armstrong Q.F. gun for use in her navy, and also the 25-mm. Maxim machine gun.

The organization and training of the troops specially reserved for fortress warfare were advanced in many European states, and Italy showed herself especially active in this direction, carrying into effect the changes in organization prescribed by the law of 1887. For the fortress artillery this entailed the increase of two of the five regiments by one division of four companies. In consequence of the increase in the number of the field artillery regiments, the numbering of the fortress artillery regiments had to be altered, and they are now numbered and their headquarters located as follows: the 25th at Ancona, the 26th at Genoa, the 27th at Rome, the 28th at Mantua, and the 29th at Capua. The instructions prepared for mobilization provide for the constitution of the following formations by the fortress artillery :—

1st. A brigade of fortress artillery for each army, consisting of the staff and one company (4 Officers, 225 men).

2nd. Troops for the artillery siege park; to be composed ordinarily of the materials for forming the park, guns divided into groups for transport, ammunition equally in groups, supplementary group (laboratory, stores, tools, materials), and the troops themselves consisting of the artillery train for the military vehicles and twenty-four companies of fortress artillery.

3rd. Garrison troops for the fortified places within the theatre of war.

4th. Garrison troops for the coast batteries.

5th. Artificers for the army artillery park.

The effect of the reorganization of the engineers has been to increase the available force of that arm from 7,000 to 8,000 men. A further step in the reorganization of the fortress troops has been to form a separate class of Officers from those employed in fortresses, to be attached to the infantry. The list consists of 6 Colonels, commandants of fortresses or forts; 9 Lieutenant-Colonels, and 16 Majors, as commandants of forts or assistants to the commandants of fortresses; 19 Captains, as commandants or assistants; and 16 Lieutenants as assistants. Besides the instruction in firing and the ordinary duties of a fortress, regular fortress manœuvres are held for all the troops allotted to them.

Russia has also taken steps to give the necessary training to the reserve

cadre-troops, which would be in great part allotted to the defence of fortresses in war. The composition of the fortress artillery in Russia for war purposes is as follows :—

1st. The siege park, consisting of 6 fortress battalions and 1 transport division.

2nd. 50 fortress artillery battalions, each of 4 companies (except two, which have 5).

3rd. 6 independent fortress artillery companies, distributed throughout the country.

4th. 3 fortress artillery detachments, each of 100 combatants, in Odessa, Nikolaief, and Astrabad.

5th. 16 sortie batteries, each of 8 guns and 2 ammunition wagons, for the larger fortresses, namely, Warsaw, Novogeorgiesk, Brest-Litovsk, Ivangorod, and Kovno.

There are in Russia two engineer siege parks, each in 4 divisions of 24 park wagons and 4 field forges. The engineer personnel for fortress warfare is formed by means of the expansion of the 5 companies into 34 reserve companies engineers (each of 224 combatants), of which 16 for siege duties and 18 for field work.

In France the amalgamation of the fortress artillery and engineers, contemplated by General Boulanger when Minister for War, has not been proceeded with.

In Part II of the Report on Fortress Tactics, the question of the value of permanent fortresses and forts is discussed with reference to the theory advanced during the autumn of 1888, to the effect that, looking to the progress made by artillery, especially in the use of projectiles charged with high explosives, permanent works have lost their defensive value. The alternative suggested was the construction, as tactical considerations might dictate, of provisional earthworks, to be furnished with armoured towers and shelters, made with the special view to their transport from place to place. In the Report the fact is accepted that, in the field, attack and defence will be more and more a matter of position warfare, and so become more or less assimilated to fortress warfare. But the argument from this, that permanent fortresses and forts can be dispensed with, is combated. The inferences drawn from the experiences of the 1870-71 war are not to be depended upon, for it is only since that war that the study of, and instruction in, fortress warfare have been seriously taken up. Had the French fortresses been defended with the knowledge and skill that have since been gained, the results might have been different. The existence of permanent fortifications does not prevent the construction, when tactical considerations require it, of strong provisional positions, as was done at Düppel, Plevna, Sebastopol, and frequently in the American war. The writer of the Report, therefore, lays it down as his opinion :—

1st. That a rational system of land defence will always be connected with such defences as are already in existence, and will not experiment with extensive changes in the fortifications.

2nd. That, looking to the value attributed to fortresses in all ages, it is not justifiable to introduce a new era of provisional fortifications, notwithstanding some examples in war which seem to favour these.

NOTICES OF BOOKS.

Battles and Leaders of the Civil War. 4 vols. 4to. T. Fisher Unwin. The Volumes weigh 5½ lbs. each and there are 750 pages of matter in each Volume, besides an ample Index and Table of Contents. Price £5 5*s.*

These four handsome volumes consist of papers which have been contributed to the "Century Magazine" during several years. They have been written by men of all ranks who were engaged on both sides during the great contest between North and South in America. The quarter of a century which has all but elapsed since on April 9th, 1865, Lee surrendered to Grant, at Appomatox Court House, the sword which he had so nobly used in the cause he had espoused, has allowed the passions of those days to die out. Throughout these various articles, from whichever side they come, there is everywhere apparent an anxious desire to do justice to the gallant men to whom the writers were opposed, and, in the main, to assist in bringing out the truth whatever it may be. Many, of course, of the chief actors have long since passed away. Stonewall Jackson was, at the very moment of the successful accomplishment of one of his most brilliant manœuvres, accidentally shot at Chancellorsville by the devoted soldiery whom he had so often led to victory. Lee, surviving the Civil War, and having refused the most tempting offers of lucrative positions in the North, died as Head of the University of his beloved Virginia, to the moral and physical recuperation of which ruined State he had devoted the last years of his always valuable life. The death of the victor of Appomatox has been too recent and too public a fact to need special record. The death, too, by the hand of an assassin of the great President at the moment when his large judgment, his devoted patriotism, his genial humour, sorely tried during four years of weary waiting and long alternations of success and failure, were at length rewarded by complete triumph, is an incident not likely to be forgotten as long as the great drama of their own history interests mankind. But, though these, the most prominent actors, have now passed away, one at least of them, Grant, lived long enough to contribute some valuable papers to this series, whilst a judicious selection from among his published writings has enabled the editors to make the contribution from his pen as complete as we could expect. Though the absence of anything direct from Lee or Jackson is a loss that cannot be adequately replaced, we have from Lee various official reports compiled during the War, and papers from many men who were closely associated with him. Still more is this the case with Jackson, whose habitual reticence would probably in any case have deprived us of much assistance from his own pen. He had the art of inspiring the most enthusiastic devotion to himself in other men, who have been delighted with the opportunity which these papers have afforded them of recording his methods of working, of describing all kinds of striking incidents in his career, and of repeating his pithy sentences.

Of the other leaders of the War, McClellan has sent more than one paper describing his schemes, his strategy, his difficulties, and pouring forth his passionate indignation against the politicians who, as he believed, shattered his career because they were personal enemies and were jealous of his influence over the "Army of the Potomac," which he certainly created, and over which no other leader ever exercised a similar spell. That story of his differences with the authorities at Washington, as to which we have much evidence on both sides, is a dramatic and interesting one. That "there were faults on both sides" is a conclusion to which all mankind is so ready to come in any similar matter that it scarcely needs

to be suggested. That, though McClellan lacked tact and judgment in his dealings with the civil authorities, who had responsibilities for which he did not make adequate allowance, and though he was not without his faults as a commander, he he was in the main right, and that those authorities were wrong, is a verdict which has already been passed by impartial history, and is fully justified by the evidence supplied in these papers. The "Century" papers acquire a special interest in regard to McClellan from the fact that, apparently, it was the excitement produced by the attempt to recall and to set forth the feelings which had been in his mind at the moment when he was, by Halleck's recommendation, withdrawn from the "Peninsular Campaign" that caused or, at least, fixed the time of his death. One night he put aside his writing at the moment when he was actually engaged in penning a sentence vehemently expressing the pride with which he and his old army would always look back to those seven fierce days of battle when, after their crushing defeat by Lee and Jackson at Gain's Mill, they successfully effected their retreat from before their skilful opponents, and, turning at Malvern Hill to face their pursuers, drove them back with heavy loss. The incomplete page is presented to us as it was written. The morning after he had been working at this paper, McClellan's sudden death appeared to indicate that the excitement of these recollections had proved too much for his overstrained temperament. Sheridan similarly lived long enough to contribute some valuable papers. His recently published memoirs will for many European readers give a fresh interest to whatever comes from his pen. Stuart, Sheridan's great rival as a brilliant leader of mounted infantry, left the stage of life at the very moment when Sheridan was, in the Richmond Raid, pushing forward to the front of it. Stuart's fall, on May 12th, 1864, almost exactly fixed the moment when ascendancy in the mounted arm passed from the Southern to the Northern side. We have here, from many men who served under him, good and clear accounts of Stuart's brilliant performances. Of the other commanders of armies, most are still alive, and I think that nearly all of them have contributed more or less to these volumes. Sherman has described his march to Atlanta, and has discussed the strategy of his great leader, for whom he is most anxious to assert a position superior to Lee as a General. That position even the greater number of those who served under Grant do not seem very willing to assign to him. It is tolerably safe to say that impartial military opinion in Europe will not accept Sherman's verdict in this respect. Nevertheless, his paper on the subject is very valuable and instructive, as is also his explanation of the vital importance of his second march from the sea through the heart of South Carolina, of which he complains with some justice that no proper estimate has been hitherto formed by military critics.

Of the other names familiar to European readers, those of Beauregard and Joseph E. Johnston, the joint victors at the Battle of the first Bull's Run, appear as the writers of many papers. Unfortunately a personal dispute as to their respective shares in the first great Southern victory mars to some extent this part of the work. It is, however, safe to say that the story of Bull's Run can never be told again after the fashion which has been current in Europe by anyone who has studied the evidence here supplied. It will, I think, be a surprise to many of even the readers of this paper to be told that the troops of Johnston transferred to the support of Beauregard did *not* disembark from the trains and march directly to the field of battle in a direction which brought them on to the exposed flank of the Federal Army. That story is treated by Beauregard, who superintended personally the movement of the troops, as a silly fiction: "Errors that have been repeated by a number of writers, and particularly by an ambitious but shallow French writer," vol. i, p. 217. The troops, in fact, detrained at the railway junction at Manassas, which is completely in rear of the right of the position of those troops who fought the battle, while the victory was gained by turning the Federal right. Stonewall Jackson, with his brigade of Johnston's Army, had been present on the previous day, and, in fact, only a relatively small portion of Beauregard's own army took part in the battle at all. It would take more space than I can afford to show how very interesting a point the facts as here recorded raise as to the kind of service which railways are likely to render to a supporting force destined to be brought on to the field of a battle, actually begun at the time they are still in the

trains. It is at least safe to say that the facts as we now have them are much more in accordance with the fixed necessities of railway movement of troops than was the somewhat sensational story on the subject which has passed for history.

From Beauregard we have also, as we have very fully from other pens, an account of the Siege of Charleston. I should like to persuade all those who have been interested in the question as to the relations between forts and ships which has occupied successive lectures and discussions in the Institution to read the story of the naval attack on Charleston as it is here told. Both naval and military Officers will, if I mistake not, find food for reflection in it. They will, I think, come to the conclusion that what Admiral Dupont and his picked Captains, assisted by the whole resources of the States, failed to accomplish, is likely to prove a tough job for any navy. At all events, for four years Charleston held out, Charleston which had been responsible for the actual beginning of the War by the attack and capture of Fort Sumter from the Federal Government, Charleston which was the most important harbour towards which blockade runners continually ran, Charleston the accursed as it appeared in the eyes of the whole North. However, the circumstances must be studied in detail in order to be understood, and I only wish here to record the fact that the evidence will be found in these pages, both of many Confederate Officers who, with Beauregard, took part in the defence, and of the Officers both of army and navy who were engaged in the attack. Dupont himself, however, died some years ago, and the vindication of his memory, which is very complete, has been necessarily left to the hands of others.

From Beauregard we have also some very interesting papers which show the part which he played in the great Battle of Shiloh in the West, in which Grant so narrowly escaped defeat. Of the actual Southern commander in that action, who was killed during the first day's fight, Albert Sidney Johnston, we have many valuable reminiscences, and we have as usual quite as complete records on the Northern side from Grant, Sherman, Buell, and others.

Beauregard also supplies most instructive papers as to the period during the last year of the war, when he was in command of the troops to the south of Richmond opposed to General Butler during the time that Lee was fighting his "Wilderness Campaign" against Grant.

Joseph E. Johnston, for whose ability all those who fought against him have profound admiration, gives his own account of the campaign against Sherman from Dalton to Atlanta. It is rather remarkable that, while at the end of that campaign when Sherman had forced his way to Atlanta, Johnston was superseded by the President of the Confederacy as having failed; and while Hood, who succeeded him, declares that the morale of the Confederate Army had been seriously impaired by the long trench work and continued retreats which had characterized Johnston's part of the campaign, the Federal Army, from Sherman downwards, seems to have hailed Johnston's removal as a positive boon. On the whole it is tolerably clear that up to the moment of the change of commanders the Federal Army, despite their considerable numerical preponderance and great superiority in matériel, had gained very little that was in a military sense decisive.

I perhaps ought to note that it is necessary to distinguish between Joseph E. Johnston, who commanded at the First Bull's Run, who subsequently at the Battle of Seven Pieces narrowly missed crushing McClellan, and in all probability would have done so had his orders been properly carried out, who, after a long delay, due to severe wounds received in that action, commanded in the West against Grant during the Vicksburg campaign and against Sherman in that of Atlanta, and Albert E. Johnston, who commanded and was killed at Shiloh in the West. The former was one of the older Officers of the War, looked up to as a military authority and soldier of the first rank by most men in both armies. Albert E. Johnston was a soldier whose short career inspired the Southern West with the highest hopes, leaving them in despair at his premature death.

McDowell, the defeated of the First Bull's Run, does not contribute anything, and appears to have died in retirement some years ago. The general effect of these papers is, however, to throw the responsibility for his defeat upon the authorities at Washington and the follies of the American public, and, to a very great extent, to redeem his fame. There is much to be said for his plan of campaign had he been

properly supported. Of the successive victims of Lee's victorious career during the earlier part of the war, Pope, the defeated of the "Second Bull's Run," "Jackson's commissariat Officer," contributes a very interesting paper which throws great light upon many facts connected with the administration of the War Office at Washington by Stanton, the Minister of War, and Halleck, who from the time of the "Peninsular Campaign" up to the "Coming of Grant" was at least the nominal commander-in-chief of all the armies of the North. Hooker and Burnside, the defeated of Chancellorsville and Fredericksburg respectively, are not among the writers on these battles, though Burnside contributes an interesting paper on his successful coast expedition. Bragg, Hood, and Ewell, among the Confederate commanders of armies, contribute papers on their campaigns. It is some indication of the portentous size of the struggle as well as of the wealth of materials contained in these volumes, that I have hitherto mentioned hardly anyone who was not in command of an independent army on one side or the other. Nor have I named all these. The careers of Forrest, George W. Morgan, Kirby Smith, Buell, Fremont, Lyon, Pearce, Sigel, Van Dorn, and Polk in the West, of which we have here many details, are full of interest. Longstreet was only at one brief period actually in command of an independent army; but, from the death of Jackson, he was Lee's most important Lieutenant. From him we have many papers, very able, very instructive, but marred by personal jealousy and personal animus of all kinds to an extent which is the case with no others in this series. His criticisms are irritating reading.

In addition to these papers by the actual leaders of the war, we have the admirable correction of independent reports from almost each of those who in each campaign held any very important subordinate positions. Thus as regards the Battle of Gettysburg, which virtually crushed the last chance that remained to the South for securing their independence, we have papers from General Longstreet savagely criticizing Lee's generalship; a most effective reply from Colonel Allan, who was on General Lee's staff at the battle; and in all twenty-seven independent papers from various hands on the different parts of this most interesting battle. Of these ten are from Confederate Officers, including, besides Longstreet himself, General Law who succeeded Hood in command of the right of Longstreet's corps. He supplies an account of part of the action, very important and hitherto much ignored in the stories of the battle. We have also from the same corps a valuable paper by Major-General Kershaw who commanded a brigade of McLaw's Division. Then we have other accounts of the famous charge of Pickett, Pettigrew, and Trimble on Cemetery Hill; two papers on the Confederate cavalry in the battle by Colonel Morley and General Robertson, and an account of the artillery from General Alexander who commanded them. Last, but not least, on this side we have from General Imboden one of the most terrible but also most graphic and interesting papers I have ever read describing his conduct of the convoy of the wounded who were sent back by Lee away from the general line of the retreat of the army, and after the most appalling sufferings due to want of equipment, want of time to tend them, and the necessity for pushing on in rough wagons over rough roads, were at last only saved from capture by a combination of ruse and valour that reads like a romance, but is full of practical suggestiveness for similar work. I think, however, that no one who reads the paper will fail to hope that it may never fall to his lot to have such an awful task to undertake.

The Federal papers on the same battle are even more ample. I suppose that no battle of that war, nor therefore certainly of any war, unless it be the battle of Waterloo, has had so much written about it as Gettysburg; yet even here an entirely new light is thrown on many incidents.

I have taken this battle as an illustration of the variety and wealth of the materials which are supplied in regard to almost every part of the war, from first to last.

One element of very considerable interest is due to the fact that men of the highest education were serving on both sides in the ranks. Thus Mr. Warren Lee Goss, who served as a full private and recounts his experiences from the time that he went up to offer himself for enlistment, offers us some very amusing and suggestive papers. These are especially valuable in the case of the Peninsular campaign, in

regard to the time when McClellan was shaping the Army of the Potomac out of a heterogeneous mass of nondescript recruits, and with reference to some of the earlier periods of the war. No one who reads them thoughtfully can, I think, fail to derive some suggestions as to the way in which great strategical movements and their consequences make their effect felt in the ranks. Similarly we have a picture from the private's point of view of Jackson's movements furnished us by Allen C. Redwood.

The Comte de Paris, who acted as McClellan's Aide-de-camp throughout the Peninsular campaign and was present with him during all the period of organization, supplies a valuable study of McClellan as a General. Everyone who has occasion to refer to a history of the war in these papers appears to be agreed that that by the Comte de Paris is by far the best that has been written.

Nor are the pens of ladies wanting to supply many reports about the war as it made itself felt in the homes and hospitals of the South.

The naval operations are very fully described. Apart from the description of the attack on Charleston, of which I have already spoken, we have most admirable accounts of Farragut's brilliant exploits in the capture of New Orleans and in Mobile Bay. We have also from several of the immediate actors reports of the fight between the "Alabama" and the "Kearsage," as well as of the fitting out and voyage of the former cruizer and of her ravages which, in the long run, proved so costly to England.

Moreover, apart from these matters of specially military and specially naval interest, there is throughout the war a feature of peculiar interest to English Officers of both services. The great rivers, which pour their waters into the Southern seas of the States, formed such a magnificent network of water communication throughout the Southern "Confederacy" that their retention was vital to the interests of the South, and it became the great purpose of the North to secure complete possession of them. That achievement was second only in importance, even if it were second, to the necessity for defeating Lee's army and seizing Richmond. Hence it happens that combined naval and military operations, such as are continually carried on by us whenever we desire to put forth our power, are a marked characteristic of the whole four years of war. The kind of co-operation which is necessary, and the kind of assistance which either service can render to the other receive continual and most useful illustration.

Anyone who first takes up these volumes will probably be at once struck by a feature in them to which I have as yet made no allusion. They are profusely illustrated. The illustrations are of all kinds. Portraits, for the most part very life-like and suggestive portraits, of all the chief actors in the great struggle are given us. Sketches of scenes of rather general than strictly military interest abound. In so far as the illustrations are used to popularize the narrative, to make the exciting stories of personal adventure, of dashing raids, of partizan warfare, more readable for the boys and the ladies, nothing could be better. Indeed I think that he would be a very dull and unenthusiastic schoolboy who could not bury himself with as much delight in many of these descriptions of real life as in the best fiction of Mr. Haggard. But when one turns to the maps and plans, which are quite as largely supplied, those which ought to make the reading of the text easy for military purposes, the gift, which as you turn over the pages to see what is in store for you, looks so promising, turns to bitter disappointment. I suppose that, with such a vast continent to deal with, and with the continual progress and change which takes place in America, it must be peculiarly difficult to get exactly accurate maps of the country as it was at a particular date. But, though no doubt the labour required would have been considerable, it would certainly have incalculably added to the value of the work if some one of the editors had read over the text, line by line, with a view to seeing that every place mentioned in it was given in some map; that the spelling of text and map was identical; and that the maps and plans were so arranged as to carry us on conveniently from the larger movements of the campaigns into the detail of the battles. Anyone who has realised the unspeakable comfort it is in studying the campaign of 1870 in the Prussian Official History, to have this work done for one with an almost ideal perfection, is perhaps a little spoiled for any military book that does not come up to that high standard. But I entertain so very high an idea of the value of these four volumes, which it must have

been both a most laborious and a most costly task to bring out, that I cannot refrain from expressing very strongly my regret that there should be anything in them which will, not to put too fine a point on it, certainly make all real military readers out of temper with the editors. There is nothing that I know of that is so annoying as just to miss being able to follow out a most interesting series of operations because you cannot find out the places that are referred to by the writer. This, unfortunately, happens here again and again. It is the one blot on the book.

I have in this description of its chief contents not attempted to preserve any strict chronological sequence, but have instead adhered to the personal connection between the several papers contributed by the various writers. My motive has been this. To my mind the great value of the book depends on the essentially personal character of the papers, and the variety of the lights which are thus thrown upon the different phases of the war. A connected, a well-reasoned, an ably-written history has, of course, a special value of its own. It would, perhaps, hardly be possible for a reader who knew nothing from any other source of the sequence of the events of the American War to arrive at an absolutely complete and connected knowledge of the whole history of the struggle from these papers alone. I do not know that there would be many gaps left unfilled if he worked through them with the distinct object of constructing for himself such a history. But the labour would certainly be considerable. On the other hand, looking at the matter from the point of view of a soldier who desires to fit himself, by acquiring the experiences of others in the past, for safely undertaking the awful responsibility of commanding men, whose lives are in his hand, I cannot imagine anything more instructive than such a set of papers as these. After all, the difficulty in reading military history is usually to get a graphic picture of the facts as they presented themselves to the people who were engaged in them. The historian is obliged, in order to produce a true and connected narrative, to compare, to collate and to summarize. In doing so the personal element is almost completely expelled, except in regard to the actual chiefs, and perhaps in regard to specially important traits in certain subordinates, who have directly influenced events. Now this personal element, the presentation of which brings before us the way in which others have had to deal with the great problems of war, is of incalculable importance in making real and lively the picture of events. By itself, if no attempt had been ever made so to collate the experiences of war as to show what principles tend to shape the course of events, and to determine success and failure, no doubt this would not offer very clear help to one who studies the past in order to realize the future. But that is not the case. The general principles of the conduct of armies are in the main simple enough, and are easily known to any one who takes the trouble to make himself acquainted with them. Only in war, as it has been well said, it is the simple that is so very difficult. What then can be more interesting to any one who has at all realized the genius for war of such a man as Lee, than to have supplied to us, as we have here, reports of conversations between Longstreet and Lee as to the principles on which, for instance, the campaign which actually led up to Gettysburg should be conducted, and then to see in practice what Lee did, and to realize why he did it; or, again in Jackson's case, to have, from subordinates of different ranks, statements of the effect of Jackson's action upon them, to see how his reticence and his principle of letting no one know what he was doing, provoked this man, or that, how Jackson's action came to be justified in their eyes, what the method of his rapid marches in detail was, what his avowed principles of action were, and how he applied them, where he missed his strokes, and where he made good his blows. If I might express the element in these papers which has given me the greatest satisfaction in reading them, I should say that it was the flesh and blood in them. And this does not apply merely to the greater leaders. From the variety of points of view, and the variety of the ranks of the men who have contributed to them, you get a sense of dealing with armies of flesh and blood, and not with mere war game counters, unique in my experience of history. To some extent Kincaid's "Rifleman in the Peninsula," and "Random Shots by a Rifleman," and Mercer's account of his own experiences in the Waterloo campaign are works which, like Gleig's "Subaltern in the Peninsula," contribute towards the

same effect as regards Wellington's campaigns. But the volume and extent of experience collected in these "Century" papers is so enormous that I do not know where anything to compare with them, or anything to be named with them, exists in regard to any other war. Of course it follows from the very nature of the case that every reader is left very much to draw his own conclusions, and probably the conclusions that different readers will draw, as to some of the points which remain in dispute, will be very different. Those who want *ex cathedrâ* decisions as to what ought to have been done in this case or that, or who was to blame for this disaster or that blunder, will not find them here. Not that there are not plenty of writers who assert their own views with sufficient dogmatism, but that usually if one man curses a particular proceeding from one mountain top, another blesses it altogether from the top of the opposite mountain.

Under these circumstances, I think, that not a few readers will be glad to have some critical guidance through such a mass of conflicting views. Fortunately I am able to tell them where they will find just such a military study of these papers. Indeed, one chief purpose which I had in view in accepting the editor's proposal that I should give here this sketch of the contents of these volumes, was to draw attention to another series based upon them, the existence of which is, I fear, likely to be unknown to many English Officers. The "North American Review" is, I believe, the oldest of the great American reviews of the type of our "Quarterlies." It has been, within recent years, restored to all, and more than all, its former vigour and influence, by the energy and ability of its late editor, Mr. Allen Thorndike Rice, whose recent sudden death, at the moment that he was starting for England on one of his many visits to this country, startled his many English friends. Of the extent of its circulation in America some conception may be formed from the fact that a copy, which happens at this moment to lie before me, to which Mr. Gladstone contributed a paper on Colonel Ingersoll, is part of the sixty-ninth edition of that number. To draw attention, therefore, in these pages to any papers that may be coming out in such a periodical seems, if one may say it with all respect to our valuable Institution, rather like announcing the existence of the "Times" through the columns of the "Skibbereen Eagle." But, so far as I have observed, the "North American Review" is not as well known in England as it ought to be. I cannot myself get it from Smith's circulating library. I see it on no club table. Mudie does not appear to circulate it. Therefore, I think, I shall do a service to many readers of this journal if I mention that Lord Wolseley is engaged in writing for the "North American Review" a series of exhaustive articles, critically examining the military conclusions to be drawn from these papers on the American Civil War. About four numbers of this series have already appeared. The third, which is the last I have seen, carries the subject about half way through the second volume, so that in all there will apparently be about seven or eight articles. He has examined consecutively each campaign and battle of any importance, and has discussed the evidence furnished in these papers with regard to it. As he was himself present with Lee's Army during the Antietam campaign, his critical remarks are interspersed with personal recollections. As he was during the whole course of the Civil War, from the time of the Slidell and Mason affair and the landing of our expeditionary force in Canada, watching the campaign whilst himself on the American Continent, and studying from day to day every scrap of information that could be gathered about it, he starts with an intimate knowledge of the whole story which, other things apart, cannot but be of service to those who feel the want of a collecting link in the reading of these valuable, but not always very consecutive papers. The articles in the "North American Review" have already been attracting a very great amount of attention in America, and have been very kindly received there. Indeed, as far as I have ascertained, their only hostile critic has been the late President of the Southern Confederacy, Mr. Jefferson Davis. As Lord Wolseley's view, that the mistakes of the President were the principal cause of the failure of the Confederacy, has been already expressed in articles written for English magazines, it is not very surprising that Mr. Davis and Lord Wolseley should somewhat differ in their views of the war. Unfortunately for the ex-President, the "Century" papers are full of the severest criticism of his conduct of the war, both from a

political and military point of view. All those criticisms proceed from those who were devotedly attached to the cause of which he was the ostensible leader. The feeling among all who write on that side of the question appears to be pretty much what Lord Wolseley expressed in an article in "Macmillan's Magazine" on General Lee a year or two ago. Naturally, therefore, Lord Wolseley has taken occasion to cite this confirmation of his views. Equally naturally President Davis, who did not like the article on Lee, likes the articles in the "North American Review" still less.

I do not propose myself to attempt in these pages to do more than suggest to the readers of this journal the rich field which lies open to them in the "Century" volumes and in the "North American Review" articles. To attempt in such space as is here possible any critical study myself of these four years of war over a continent in which at almost every moment about three independent campaigns were going on, and not unfrequently a good many more, would be absurd.

On the question, however, of the value, for the purposes of military study, of this war, I have some remarks to make. To those who think that a little practical test is worth a good deal of abstract discussion, perhaps the most convincing evidence I can offer of the truth of the opinion, I strongly hold, that the War is full of instruction of all kinds for soldiers would be to ask those, who have not already done so, to read the admirable short study of the Fredericksburg Campaign, published anonymously about two years ago by an English Officer. Those who have read it will not, I think, require to be convinced that, at least from some parts of the war, valuable lessons for present use may be deduced. There is, however, perhaps one misfortune in taking Fredericksburg as a representative campaign; that of all Lee's earlier campaigns it was the one that depended most, for the crushing part of the Confederate success, upon the effective use of defensive works and a defensive position. So used, it rather tends to confirm an impression in regard to the whole of the war, which was very general immediately after its conclusion. That impression was, I believe, very happily summed up by an able English soldier in a conversation with General Grant. That man of few words happened to be travelling on board ship with the Officer in question, and asked him what lessons he thought were to be deduced from the American War. "Spades and Mounted Infantry," was an answer so laconic, and, if it be a true summary, so pithy, that it might have come from General Grant himself. I believe that, certainly in form, probably in matter, the answer much pleased the General. I do not think, however, that the effect of the complete view of the whole war presented by these papers tends to confirm the conclusion which the words are apparently intended to convey. Apparently their meaning is that under the conditions of modern war the chief mode of fighting must be that of infantry behind earthworks, and that of men with firearms on horseback replacing cavalry. Neither of these deductions appears to me to be soundly drawn from the premises. I may, perhaps, venture to speak with the more freedom on the subject, because I have always combated the exactly opposite conclusion, which was as, I think, too hurriedly drawn from the experiences of the War of 1870. In that war the continual successes of the attacking Germans were quoted to show that the change in weapons had increased the advantages of attack over defence. In both cases alike it appears to me that hasty conclusions have been drawn from not taking account of all the facts. It is quite true that during the last year of the Civil War, both in the West and East, a great part of the fighting came to be a contest of earthworks against earthworks. It is quite true that at Gettysburg, at Fredericksburg, at Cold Harbour, and elsewhere, disastrous defeat was inflicted on troops attacking. But in the first place, during the greater part of the war, rapidity in marching and manœuvring asserted all its old supremacy. I would particularly ask anyone who does not recall the extent to which this feature was prominent, to read Lord Wolseley's summary of Jackson's operations in 1862, and his comments on their success. In the Shenandoah Valley, Jackson in 1862, with a total force of 17,000 men, paralyzed the action of at least 80,000 men, according to the very careful estimate of the Northern editors of these papers. He was actually fighting 44,840 of these in the valley, not including 7,000 more at Harper's Ferry, who had to be

reckoned with as part of the army against which he was employed. He always contrived to be in superior strength on the successive battle-fields in which he then fought, and, at the end of the campaign, having left the Federal Army on that side of the theatre of war, despite its overwhelming numerical superiority, helplessly awaiting his attack in some unknown direction, and, having created the greatest alarm at Washington, lest his little army should make its way thither, instead of any of the 80,000 finding their way towards Richmond, he transferred secretly his entire force to the Peninsula. There his arrival enabled Lee to devise one of the most telling strokes of the war, one which in fact resulted for the time in relieving Richmond from all danger of attack. These are not results which could have been secured by any merely defensive operations, however brilliantly devised. The lessons they teach are not those of "spades" or even of "mounted infantry," though Jackson's "foot cavalry" almost, from their rapidity of movement, approached the character of that valuable arm.

Again, at Chancellorsville, at both the Bull's Run battles, and in many of the Western campaigns, notably in Grant's brilliant series of movements and victories just prior to the Siege of Vicksburg, the old principles of successful strategy, ruse, concealment, accurate information of the enemy's movements, sudden transfer of force, concentration against a dispersed enemy, moral ascendancy, the seizing of the initiative, the doing of the unexpected, asserted all their old supremacy.

Those who believe in the spade as the chief weapon of modern war will find among the writers of this series an able advocate of their views. General Longstreet tells us that, prior to the Gettysburg campaign, he pressed upon General Lee the importance of adhering strictly to the method of defensive tactics alike in offensive and in defensive strategy. I do not know what effect his arguments will produce on others. On me they leave just the opposite impression to that which he would wish. He does not tell us very clearly what was Lee's share in the conversation. He rather makes one disposed to think that, though he declares that Lee accepted in principle the truth of what he urged, Lee was in fact strictly adhering to the advice "Take all men's counsel, and reserve thy judgment." At all events, on the very next occasion on which Lee had to choose between taking and rejecting Longstreet's proposals, he deliberately rejected them. Unfortunately for him, he had to rely for the carrying out of his schemes on the very man whose advice he was rejecting. If one point comes out more clearly than another from the consensus of opinion presented by these papers, it is that, had Jackson been in Longstreet's place at the Battle of Gettysburg, Lee's schemes would have been crowned with success, and the Battle of Gettysburg would have been an overwhelming victory for the assailants. Longstreet, with no adequate appreciation of the genius of the chief under whom he was serving, had no heart in carrying out a method of fighting of which he disapproved. The result was the ruin of the Confederate cause. Moreover, there is a narrowness in the very statement of General Longstreet's views which at least suggests that he suffered from a difficulty from which few soldiers are able to emancipate themselves. It is very hard for any of us to avoid attaching an altogether undue importance to our own particular experiences. Longstreet tells us that the great argument that he pressed upon Lee in behalf of the adoption of a purely defensive tactical attitude, was the brilliant success of his own wing of Lee's Army at the Battle of Fredericksburg. Even in his view of that battle, he appears to me altogether to do injustice to the skill of Lee's strategy, which induced the Federal commander to attack, and to the importance of the unexpected presence of the whole of Jackson's force on the right wing at a time when Burnside supposed that the greater portion of them at least were miles away. Moreover, you cannot base the whole conduct of a war upon the assumption that you will always have to deal with an enemy who will attack just when he ought not to do so. Now, at Fredericksburg, even Burnside recognized that the attack was a preposterous blunder. He was forced into it by the Washington politicians. Yet again the historical examples by which Longstreet enforces his conclusion are curiously wanting in accuracy. Describing his own predictions in regard to the War of 1870 at the moment when MacMahon was beginning the disastrous march which led to Sedan, he says (p. 354, vol. iii) that he declared that the Prussians would interpose, and "force McMahon to attack."

"Had we interposed between Meade and Washington our army, in almost as successful prestige as was that of the Prussians, Meade would have been obliged to attack us wherever we might be pleased to have him. He would have been badly beaten like the French, and the result would have been similar." From which it is to be inferred that General Longstreet supposes that the Battle of Sedan was one in which the French were the assailants and the Prussians in occupation of a defensive position. As in fact throughout the day the Germans were engaged in a series of fierce attacks upon the French, and only when the end was near were the French forced into hopeless and disjointed counter-attacks, the historical argument loses its point. In fact, had Longstreet, by throwing in his whole force, succeeded in capturing the Peach Orchard and the two Round Tops, driving in the Federal left, the result would have been almost exactly similar to what happened at Sedan. The Federal right and great part of the centre, if they had succeeded in extricating themselves at all, could only have done so by most costly counter-attacks upon the Confederates in possession of the positions which they had seized.

That a war of intrenchment was forced by circumstances on General Joseph E. Johnston during the Atlanta Campaign, and that, from strategical considerations connected with the impossibility of shifting his line of supply, Sherman was forced to reply by a system of counter-intrenchment instead of manœuvring the Confederates out of their works cannot be denied. Nor is it doubtful that, when after this Hood substituted a series of dashing movements and dashing attacks for the Fabian policy of Johnston, the result was disastrous to the Confederates. Similarly, during the latter part of the war, the contest between Lee and Grant resolved itself virtually into a great siege, of which, of course, intrenchment and counter-intrenchment, mining, and assaults became the chief factors. That, however, was simply because the limits within which Lee could operate had been gradually, by the overwhelming force of the Northern armies, circumscribed. Moreover, both in the Atlanta Campaign and before Richmond, there are not a few indications of the old danger that those who learn to fight successfully behind intrenchments shall learn not to fight as vigorously when not protected by them. Something of the old Confederate dash and go seems to have been lost both in east and west from the time that the spade became the great weapon of the war. I think also that any soldier who reads the very able and suggestive papers of General Beauregard will see that there were opportunities for successful strategy in the field in the old sense of the term prior to the junction of the armies of Butler and Grant which would probably have had very important results, and might have been far better for the Confederacy even at the last than the recourse to the spade work which in the long run proved so disastrous to them.

For my own part, I am convinced that the fair conclusion from the whole evidence as it here lies before us is, not that the spade is an instrument to be discarded, nor yet that it is to be treated as the queen of weapons. But here, as always in war, balanced judgment, a knowledge of the power of attack, of the advantages of the initiative, and also of the overwhelming material and local gain which modern weapons give to the defensive, when properly applied, are the important matters. The whole of the circumstances, the moral and material condition of both armies, the nature of the country, and the opportunities presented for either course of action, must be all considered in each case by the man who would succeed. A fixed rule will not apply. Therefore it is that such a study as these papers afford is of such great value. They suggest the infinite variety of circumstances which present themselves in war. They indicate how sound principles work themselves out amid the variety of circumstance. They are, in fact, an enormous collection of experience. It is true that the conditions were in many respects peculiar, that the armies were not exactly like the trained regular armies of Europe. But it is idle to suppose that by the end of four years of war the greater proportion of the combatants had not become for practical purposes more effective fighting soldiers than the majority of the modern short service men who have not spent as long a time in peace service as these men spent in the training of war. From the time that McClellan formed the Army of the Potomac, that army at all events was as regularly organized, as completely equipped, and almost as strictly disciplined as most European armies. The Southerners had the advantage

of commanders of greater genius. Their men had greater devotion to the cause, and had perfect confidence in their leaders. That they had to depend for successful action on equipping themselves from the resources of their opponents does not seem to me, during at least the earlier years of the war, to have been so serious an injury to their cause as the fact that it was seldom possible to follow up victory because of the tendency of the men to lose their cohesion, and often to some extent to disperse to their homes when victory had been won. Again and again, it looks as if a vigorous pursuit ought to have altogether broken up the defeated Federal armies. Again and again, the chance was missed. Certainly it was not because either Lee or Jackson did not appreciate the importance of pursuit. I think that there are indications in these papers that some such cause as that which I have described powerfully operated. Enthusiasm properly disciplined is an enormous power. Certainly the inference which one draws from these papers is not that enthusiasm is a substitute for organization or discipline.

In conclusion, I cannot too strongly recommend the book to the attention of those who are for any reason interested in the records of war. If the readers of this paper will endeavour to insist on the presence of these volumes and of the "North American Review" in all libraries, permanent and circulating, they will, I think, be doing useful service.—J. F. Maurice, Colonel.

Rambling Reminiscences of the Punjab Campaign, 1848–9, *with a brief Sketch History of the 24th Regiment from* 1689–1889. By Lt.-Col. A. J. MACPHERSON. Chatham: Mackay, 1889. Pamp. Pp. 104. Price 1*s.*

We wish all rambling reminiscences were as well worth reading as these.

The Woolwich Handbook. London: Clowes, 1889. Pp. 120. Size $7\frac{1}{4}'' \times 5'' \times 0\frac{1}{2}''$. Weight under ½ lb. Price 2*s.* 6*d.*

This is a very useful little book for parents and guardians having the Artillery or Engineers in view for those whose future is to be determined by them. It gives a great deal of useful information as regards preparation for their entrance into the R.M. Academy and work there. At p. 20, however, we read, "The reluctance to any aspect of advertising on the part of certain preparatory schools of note has caused the editor to abandon an intention to indicate by name some of the longest-established and best-known preparatory schools." But in the very next paragraph he proceeds to name one school, from the proprietors of which, "having obtained permission to express his conviction that their school (from which his two sons obtained scholarships at well-known public schools) fulfils all the requirements above detailed, he has much pleasure in recording his high opinion of its merits." We congratulate both the crammers and the tradesmen whose names are mentioned in this book on an advertisement "free, gratis, and for nothing;" but the appearance of these names is a decided disfigurement in an otherwise, as we have said, useful book.—L. A. H.

Two Lectures (enlarged for Publication) *delivered at the School of Musketry, Hythe, June,* 1889. By Colonel W. MACKINNON, Chief Instructor. Hythe: Payne. Pamp. Pp. 18. Price 6*d.*

These two lectures are on the volley and on the instruction of recruits and trained soldiers, and are well worth reading.

The Command of Artillery in the Army Corps and the Infantry Division. By Major-General HOFFBAUER, Commanding 5th Prussian F.A. Brigade. Translated from the German by SPENSER WILKINSON. Manchester: Cornish, 1889. Pamp. Pp. 38. Price 2*s.* 6*d.*; postage 2*d.*

The title of this pamphlet is somewhat misleading. The pamphlet is really one of those excellent studies in applied tactics similar to others which Captain Spenser Wilkinson has from time to time given us through the medium of the Manchester Tactical Society. It follows the course of an imaginary action, mainly from an artillery point of view, and it is full of practical suggestions.

Life of the Marquess Wellesley, K.G. By Colonel G. B. MALLESON, C.S.I. Pp. 233. Size $7\frac{1}{4}'' \times 5'' \times 0\frac{3}{4}''$. Weight under 14 oz. Price 2*s*. 6*d*.

Life of the Marquis of Dalhousie. Captain L. T. TROTTER. Pp. 228. Size $7\frac{1}{4}'' \times 5'' \times 0\frac{3}{4}''$. Weight under 14 oz. Price 2*s*. 6*d*.

These are two volumes of the Statesmen Series, edited by Lloyd C. Sanders, and published by Messrs. Allen and Co.

Prospectus and Plan of Elson's Maritime Code of Signals. Calcutta: Banirji, 1889. Pamp. Pp. 11.

Mr. Elson gives here a specimen of a new scheme of universal marine flag-signalling, and supports it also by the names of 155 shipmasters and others who approve of his scheme.

Embarkation and Disembarkation of Troops. By Colonel G. A. FURSE, C.B. Portsea: Holbrook and Son, 1888. Pamp. Pp. 74.

Colonel Furse is an authority on this subject, and in this pamphlet gives the result of practical experience gained whilst employed as Embarking Staff Officer at Portsmouth.

Army and Navy Calendar for the Financial Year 1889–90. 9th edition. Compiled from authentic sources by JOHN HAZARD. London: Allen and Co. Pp. 295. Size $8\frac{1}{2}'' \times 5\frac{1}{4}'' \times 1''$. Weight under $1\frac{1}{2}$ lbs. Price 2*s*. 6*d*.

A very useful publication, giving a great amount of information about Army and Navy matters. The maps of stations are a prominent feature in the work. It is a sort of Service "Whitaker." Can we say more?

Words on Wellington, The Duke—Waterloo—The Ball. By Sir WILLIAM FRASER, Bart. London: Nimmo, 1889. Pp. 344. Size $8\frac{1}{4}'' \times 5\frac{1}{2}'' \times 1''$. Weight under 1 lb. 10 oz. Price 7*s*. 6*d*.

Wellington. By GEORGE HOOPER. London: Macmillan and Co., 1889. Pp 254. Size $7\frac{3}{4}'' \times 5\frac{1}{4}'' \times 1''$. Weight under 1 lb. Price 2*s*. 6*d*.

The cry is "Still they come"; but they cannot be too many, and the more we hear about Wellington from different sources the better we shall understand him. Mr. Hooper's work is one of the series of "English Men of Action."

History of the XXth Regiment, 1688–1888. Compiled by B. SMYTH, Lieutenant; Quartermaster 1st Lancashire Fusiliers. London: Simpkin, Marshall, and Co., 1889. Pp. 410. Size $9'' \times 6'' \times 1\frac{1}{4}''$. Weight under $2\frac{1}{4}$ lbs. Price 15*s*.

We congratulate Lieutenant Smyth on the result of his labours. The Double X have found a thoroughly competent historian. The Appendix is by no means the least interesting part of the book. In it we find a specially valuable extract from a volume chiefly composed of regimental orders published by Lieut.-Colonel James Wolfe, the future hero of Quebec. The history is well worth perusal by others beyond the circle of old Twentieth men.

Life of Charles Blacker Vignolles, Soldier and Civil Engineer. By his son O. J. VIGNOLES. London: Longmans, Green, and Co., 1889. Pp. 398. Size $9'' \times 6\frac{1}{4}'' \times 2''$. Weight under $2\frac{3}{4}$ lbs. Price at Hogg's, Charing Cross, to Members R.U.S.I., 11*s*.

The career of the subject of this biography is somewhat romantic. Born on 31st May, 1793, and left an orphan when hardly a year old, he was appointed Ensign in the 43rd Regiment on the 25th October, 1794, at the age of one year and five months, but the small infant was to exchange to half-pay as being *too young to serve.* Up to the end of 1813, when he was twenty years of age, he remained on the half-pay list, and was then gazetted to the York Chasseurs. At the age of twenty he became engaged to his future wife, was transferred shortly after to the 4th Battalion Royal Scots, saw a good deal of active service, married on very small means at

the age of 24, threw up the Service about the age of 25, and then, by sheer mental power and force of character, achieved a position as one of the foremost railway engineers of the day. The book well repays perusal.

Cold Steel: a Practical Treatise on the Sabre, also on various other weapons of the present day. By ALFRED HUTTON, late Captain K.D.G. London: Clowes, 1889. Pp. 241. Size $10\frac{1}{4}'' \times 7\frac{1}{2}'' \times 1\frac{1}{4}''$. Weight under 3 lbs. Price 10*s.* 6*d.*

This is the work of an enthusiast, for no one but an enthusiast would have given us such a really beautifully got-up book in connection with "Cold Steel." It is most interesting, and the numerous illustrations are excellent.

The Naval Annual, 1888-89. By Lord BRASSEY, K.C.B. Portsmouth: Griffin. London Agents: Simpkin, Marshall, and Co., 1889. Pp. 705. Size $10'' \times 6\frac{3}{4}'' \times 2\frac{1}{4}''$. Weight under $4\frac{1}{4}$ lbs. Price 10*s.* 6*d.*

This invaluable publication is the work mainly of Lord Brassey, and as his assistants we find Mr. F. K. Barnes and Major Orde-Brown, whilst the first chapter is contributed by Rear-Admiral P. H. Colomb.

Torpedoes and Torpedo Warfare. By C. SLEEMAN., Esq., late R.N., and late Commander Imperial Ottoman Navy. Portsmouth: Griffin and Co. London Agents: Simpkin, Marshall, and Co., 1889. 2nd edition. Pp. 338. Size $10'' \times 6\frac{3}{4}'' \times 2''$. Weight under $3\frac{1}{4}$ lbs. Price 25*s.*

Mr. Sleeman is one of the greatest of authorities on this branch of warfare, and in this edition endeavours to bring the history of submarine warfare up to date.

National Defence. Articles and Speeches by Lieut.-General Sir Edward Hamley, K.C.B. Edinburgh and London: Blackwood, 1889. Pp. 198. Size $8\frac{1}{2}'' \times 5\frac{1}{2}'' \times 1''$. Weight under 1 lb. 6 oz. Price 6*s.*

Sir Edward Hamley has put forward here in a collected form his views and opinions on this important matter. They should be carefully studied by all interested in the question.

Declaration of War: a Survey of the Position of Belligerents and Neutrals, with relative considerations of Shipping and Marine Insurance during War. By DOUGLAS OWEN, Barrister-at-Law. London: Stevens and Sons, 1889. Pp. 488. Size $9'' \times 6'' \times 2\frac{1}{4}''$. Weight under $2\frac{3}{4}$ lbs. Price 21*s.*

This work combines in one volume information on the three branches of the subject, each of which has a literature of its own; and it is intended to meet that common desire for such information which becomes especially apparent whenever a rumour of impending war arises.

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